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REPORT OF THE CHIEF OF ORDNANCE.

OFFICE OF THE CHIEF OF ORDNANCE,
U. S. ARMY,
Washington, October 28, 1902.

SIR: 1. I have the honor to submit the following report of the principal operations of the Ordnance Department during the past year, together with certain remarks as to its interests and necessities.

2. The fiscal resources and expenditures of the Department during the year were as follows, viz:

Amount in the Treasury to the credit of the appropriations on June 30, 1901	$9,837,080.24
Amount in the Treasury not reported to the credit of the appropriations on June 30, 1901	8,266.18
Amount in Government depositories to the credit of disbursing officers and others on June 30, 1901	1,819,476.25
Amount of appropriations for the service of the fiscal year ended June 30, 1902, including the appropriation for armament of fortifications in the act approved June 6, 1902	8,134,507.45
Amounts refunded to ordnance appropriations in settling accounts during the fiscal year ended June 30, 1902	654,317.09
Gross amount received during the fiscal year ended June 30, 1902, from sales to officers, from rents, from collections from troops on account of losses of or damage to ordnance stores, from Chicago, Rock Island and Pacific Railroad Company, from powder and projectiles (proceeds of sales), from sales of condemned stores, from testing machine, and from all other sources not before mentioned	428,253.90
Total	20,881,901.11
Amount of expenditures during the fiscal year ended June 30, 1902, including expenses attending sales of condemned stores, exchange of powder, etc	8,792,964.24
Amount deposited in Treasury during the fiscal year ended June 30, 1902, as proceeds of sales of Government property	245,227.87
Amount turned into the surplus fund on June 30, 1902	42,164.94
Amount in Government depositories to the credit of disbursing officers and others on June 30, 1902	1,621,099.14
Amount transferred from ordnance appropriations in settling accounts during the fiscal year ended June 30, 1902	162,284.06
Amount in the Treasury not reported to the credit of appropriations on June 30, 1902	3,965.62
Amount in the Treasury to the credit of appropriations on June 30, 1902	10,014,195.24
Total	20,881,901.11

CLERICAL FORCE.

3. In accordance with the requirements of existing laws, I have made an estimate of—

1 chief clerk, at $2,500, whose present salary of $2,000 per annum is not at all commensurate with the important and very valuable service he is rendering the Department.
6 clerks of class 4 (increase of 3).
7 clerks of class 3 (increase of 2).
12 clerks of class 2 (increase of 6).
22 clerks of class 1 (decrease of 13).
14 clerks at $1,000 per annum (decrease of 5).
14 clerks at $900 per annum (increase of 7).
Making a total of 75 clerks, which is the same number as the present force, and
4 messengers.
1 assistant messenger
1 laborer.

4. The present force consists of—

1 chief clerk.
3 clerks of class 4.
5 clerks of class 3.
6 clerks of class 2.
35 clerks of class 1.
19 clerks at $1,000 per annum.
7 clerks at $900 per annum.
Making a total of 75 clerks, and
4 messengers.
1 assistant messenger.
1 laborer.

5. The present office force includes the permanent force appropriated for in the legislative, judicial, and executive appropriation act approved April 28, 1902, and includes also the temporary force authorized by the acts of July 7, 1898, February 24, 1889, April 7, 1900, and March 3, 1901. This temporary force was, by section 3 of the above-stated act, approved April 28, 1902, transferred to the classified service.

6. The percentage in each of the several grades of clerks called for in the above estimate for the fiscal year ending June 30, 1904, is the average of the percentages in all the bureaus of the War Department, except that none are asked for of grades above the fourth class and none of grades below the $900 class.

7. The experience of this office for several years past has been that many valuable clerks in the lower grades resign to accept positions in the other bureaus of the War Department and in other departments at increased salaries, the limited number of the higher-grade clerkships in this office offering no prospects for promotion to these men. During the past year four of our clerks receiving $1,200 per annum and four receiving $1,000 per annum have resigned to accept positions, at

increased compensation, in other departments of the Government and in outside employment. The Department is thus depleted of its best material from which to make selections for filling vacancies occurring in its highest and most responsible positions. This has proved a practical source of embarrassment.

DISPOSITION OF CONDEMNED CANNON, ETC.

8. The act of Congress approved May 22, 1896, provides—

> That the Secretary of War and the Secretary of the Navy are each hereby authorized, in their discretion, to loan or give to soldiers' monumental associations, posts of the Grand Army of the Republic, and municipal corporations condemned ordnance, guns, and cannon balls which may not be needed in the service of either of said Departments. Such loan or gift shall be made subject to rules and regulations covering the same in each Department, and the Government shall be at no expense in connection with any such loan or gift.

9. Under the provisions of this act donations have thus far been made to Grand Army posts, monumental associations, and municipal corporations to the extent of 866 cannon and 11,752 projectiles. The donations during the past fiscal year are shown to be 101 cannon and 955 projectiles.

SALE OF OLD ORDNANCE AND ORDNANCE STORES AT ARSENALS AND FORTIFICATIONS UNDER REVISED STATUTES, 1241.

10. The proceeds of sales of condemned ordnance material at the various ordnance establishments and other military posts during the past fiscal year, amounting to $244,787.52, has been deposited in the Treasury of the United States.

GATHMANN GUN.

11. Since the date of the last report of the Chief of Ordnance a test, especially directed by Congress, of the 18-inch Gathmann gun, in comparison with the 12-inch service rifle, has been made. In its final and much modified form the Gathmann system consisted only of an exceptionally large gun and projectile, with nothing of special invention except the detonating fuse. The object was to throw a large charge of high explosive, the capacity of the projectile being increased at the expense of its strength until there was no expectation of penetration of armor before explosion. All previous experiments had resulted in the general professional opinion that a projectile exploded on the outside of an armored structure would do it less damage than a similar projectile without explosive charge, but with power of penetrating the armor. This experiment, tried on a larger scale than any which had preceded it, confirmed the opinion already existing. The conclusion of the joint board of army and navy officers which made the test was as follows:

> There is nothing in the Gathmann system to recommend its adoption in the public service of the United States or to warrant further experiments.

The complete report of the board has been submitted and published. The total cost to this Department of all experiments with the Gathmann system, from the time of its submission in its original form, has been $135,062.60.

EXPERIMENTAL MUSKET.

12. The improved musket, which was referred to in the last report of the Chief of Ordnance as being under construction, has been completed and tried, with very satisfactory results. The principal points of its difference from the present service musket are the use of two lugs instead of one for holding the bolt against the rearward pressure of the powder, with resulting increase of strength sufficient to enable a velocity of 2,300 feet per second to be obtained; the housing of the magazine in the stock directly below the chamber instead of having it project to one side. In addition to these there are various changes of details which both improve the rifle and cheapen and accelerate its production. The arm is supplied with a cleaning rod which can be partially pulled from its place below the barrel and held with a catch so as to form a bayonet. The "rod bayonet," as it is called, has been considered before, but has never received a thorough trial in the service. Its great advantage is that it lightens the weight made up of the gun, bayonet, and bayonet scabbard, and by dispensing with the latter two as separate articles to be carried permits the soldier to carry with him an intrenching tool of sufficient size and weight to be serviceable. There are differences of opinion as to the value of the rod bayonet; although less effective as a bayonet alone than the one now in use in the service, it is undoubtedly of some value in converting the musket into a pike, and in view of the increasing prominence of the intrenching tool and the decreasing occasion for the use of the bayonet its experimental substitution is in line with apparent progress in subordinating the latter to the former. The principal elements of the new piece in comparison with those of the present service rifle are contained in the following table:

	Springfield magazine rifle.	Service magazine rifle.	Mauser 7 mm. rifle.	German military rifle.
Caliber ... inches..	0.30	0.30	0.275	0.311
Rifling:				
Number of grooves	4	4	4	4
Depth of grooves ... inches..	.004	.004	.0049	.004
Twist, one turn in ... do....	10	10	8.66	9.45
Weight of bullet ... grains..	220	220	173	226.82
Weight of charge ... do....	43.3	37.6	38.58	41.2
Weight of complete cartridge ... do....	451.15	438.85	385.63	430.24
Initial velocity ... feet per second..	2,300	2,000	2,200	2,145
Remaining velocity at 1,000 yards	958	901	895	906
Muzzle energy ... foot-pounds..	2,581.6	1,952	1,857.4	2,315
Striking energy at 1,000 yards ... do....	447.9	396.2	307.4	413
Penetration in white pine at 53 feet ... inches..	54.7	45.8	50.8	....
Weight of rifle, including bayonet and scabbard, pounds	9.47	10.64	10.5	11.54
Weight of rifle, including bayonet, scabbard, and 100 cartridges ... pounds..	15.91	16.91	16.18	17.68
Capacity of magazine ... rounds..	5	5	5	5
Maximum ordinate of 1,000-yard trajectory ....feet..	20.67	25.8	24.47	23.73

13. The construction of 5,000 of the new muskets has been authorized for issue and trial in the service. The preparations for their manufacture at the Springfield Armory are progressing steadily and are made upon a scale which will permit the production of the pieces at the rate of 125 per day of eight hours. When the manufacture shall commence it will thus be seen that the total number authorized can be produced in about forty days, and it is expected that they will be ready for distribution in the coming spring.

14. The only radical improvement in muskets which is now known to be under study is the application to these arms of the automatic principle, to the extent of causing the musket itself to effect its own reloading upon discharge. The principle has been already applied with some success to pistols, and its advocates claim that it is logically in the line of development of the magazine rifle, in reducing to a minimum the interval between aimed shots. Both tactical and mechanical questions are involved in the consideration of the possible desirability of the substitution of a semiautomatic musket for the hand-operated magazine rifle. Up to the present time mechanical invention has not solved its part of the problem, and no rifle of the class has been presented to this Department for examination and test, although its willingness to take the subject up has been signified whenever occasion has offered.

15. In the meantime the question of the accumulation of a sufficient reserve of small arms to meet possible requirements is one of importance. Congress has indicated its appreciation thereof by increasing, in the appropriation act last passed for the purpose, the amount to be expended in the manufacture of small arms from $1,100,000, the previous figure, to $1,700,000. Under these circumstances it is important to decide whether the manufacture of the present service rifle shall continue at the current rate until such period as the new gun shall have been issued and tested, and the preparations in the way of machines and fixtures shall have been made for its entire substitution for the present arm. The time required for a determination to be arrived at in this manner would be sufficient to very considerably increase the number of the present service rifles on hand, and it is the view of this Department that there would be less risk of error in assuming that the new musket, of which the promise, after very thorough test, is so favorable, is going to be sufficiently superior to the present one to take the place of the latter, and in proceeding with preparations for its manufacture accordingly, than in continuing to accumulate muskets of the present type to be probably discarded and replaced.

16. The present manufacturing capacity of the Springfield Armory for the service musket is at the rate of about 200 per day of eight hours; to this rate will be added that of 125 per day of the new arms, to be attained at some time in the early part of the next calendar year. Preparations will be made to continue the manufacture of 125 of the

new arms per day after the completion of the 5,000 now authorized, and to gradually change the machines now used in building the present musket to adapt them to the manufacture of the new one, and also to so arrange the additions to the plant now in progress that when the capacity of 400 guns per day, which is that now contemplated for the future at this armory and for attaining which appropriations have already been made, shall be reached, the establishment will be able to turn out the entire 400 guns per day of the new model; and this with the least interruption practicable of the current manufacture.

17. There is now approaching completion at the Rock Island Arsenal an armory with a manufacturing capacity of 250 muskets per day of eight hours, although it will not be ready for operation for at least a year because of the postponement of the installation of certain machines and of the equipment of many with fixtures until such time as the type of rifle to be manufactured shall be decided. For the reasons stated above, preparations will now be made under the supposition that the new rifle under construction is to be adopted, the risk of error being considered less undesirable than further delay. When the two establishments shall be fully equipped, their total capacity will be 650 arms per day of eight hours, and the question will arise as to the extent to which they are to be operated. Assuming the number 500,000 to be a proper reserve, production at the present rate of the Springfield Armory, 200 per day, would cause the supply to be accumulated in something over eight years. With the contemplated capacity of 400 per day at the Springfield Armory this period would be reduced to four years, and with the full capacity of both establishments working eight hours per day the time required would be about two and one-half years. As considerations of the employment of labor would be against the policy of greatly diminishing the rate of manufacture after so short a time, an output below the full capacity of each establishment will most likely be found desirable. It is necessary that both plants shall be kept in operation in order to preserve at each establishment the necessary skill and experience for the operation of its plant; and if each be employed at about half its capacity the total output will be 325 guns per day, at which rate the reserve of 500,000 will be reached in about five years. In case of emergency, both establishments could be operated upon the basis of a twenty-hour day, and under these circumstances would be capable of a daily output of 1,500 rifles, which in three months, after the necessary workmen should have been secured, about the time necessary for assembling a volunteer force, would provide 135,000 arms.

Details as to the progress of the establishment of the Rock Island Armory appear in the portion of this report especially devoted to that arsenal.

WINCHESTER RIFLES.

18. The 10,000 magazine rifles, caliber .30, purchased in 1898 and 1899 upon the recommendation of the Commanding General of the Army, and reported upon unfavorably from the service, are still on hand. As they use the service ammunition, they will be kept, without recommendation as to their ultimate disposition, until such time as the proper reserve of other arms shall have been accumulated.

NEW FIELD MATERIAL.

19. A competitive test of field material, under a programme prescribed by the Board of Ordnance and Fortification, has been made by this Department during the past year. Material representing eight systems was tested, all using fixed ammunition. It can be divided into three general classes as follows:

Class I.—The gun and carriage recoiling as a unit.

Armstrong 3-inch rifle mounted upon a rigid carriage having a spade connected with the axle and with the trail by an elastic union, known as the Clarke pattern. The carriage provided with a screw brake.

Cockerill-Nordenfelt 75 mm. (2.953 inches), Belgian pattern, with Nordenfelt eccentric block breech mechanism. The gun mounted in a cradle with a movement in azimuth on the carriage; the latter provided with recoil brakes in the form of shoes under the wheels.

Class II.—The gun having a short recoil on the carriage, the latter provided with hydraulic cylinders and counter-recoil springs.

Ordnance Department model of 1900, 3-inch rifle with Gerdom breech mechanism. The gun mounted in a cradle having a movement in azimuth on the carriage; the latter provided with a trail spade and a screw brake.

Vickers-Maxim 75 mm. (2.953 inches) rifle mounted in a cradle having a movement in azimuth on the carriage; the latter provided with a fixed trail spade and with wheel shoes.

Class III.—Guns having long recoil on the carriage; the latter having hydraulic cylinders and counter-recoil springs.

Bethlehem No. 2.—Three-inch rifle mounted upon a Lewis carriage. The body of the carriage having a movement in azimuth along the axle. The carriage provided with a fixed trail spade and with wheel shoes.

Bethlehem No. 3.—Three-inch rifle mounted upon a Bethlehem carriage provided with counter-recoil springs in the trail, connected with the piece by wire ropes, and fixed trail spade and wheel shoes. The body of the carriage having movement in azimuth along the axle. Wheel shoes.

Ehrhardt 3-inch rifle, Norwegian pattern, with Nordenfelt eccentric block breech mechanism.—The gun mounted in a cradle having a move-

ment in azimuth on the carriage; the latter provided with an extension trail, a fixed trail spade, and a screw brake.

Ordnance Department model 1901, 3-inch rifle with Gerdom breech mechanism, mounted in a cradle having a movement in azimuth on the carriage; the latter provided with a fixed trail spade and a lever brake.

20. The Bethlehem Company also sent to the proving ground a gun and carriage, designated as Bethlehem No. 1; these were, however, shortly withdrawn by the company and not subjected to test.

21. The trials comprised tests for velocity, accuracy, rapidity, rapidity with accuracy, maintained rapidity; the behavior of the material with defective ammunition, under conditions of dust, rust, and excessive charges; its action on platforms of clay, loam, sand, rock, and macadam; also when fired with the trail rigidly supported against a post set in the ground. The limbers with chests completely filled were subjected to jolting on a vibrating table to assimilate the effect of bad roads. The material was subjected at Fort Riley, Kans., to a practice march of 150 miles and to all the maneuvering necessary to constitute a complete field trial.

22. Comparatively early in the test it became evident that those types in which the gun was given a long recoil upon the carriage were superior to all others, and the latter were withdrawn from further test. Finally but three systems, viz, the Bethlehem No. 2, the Ehrhardt, and the Ordnance Department, long recoil, were carried through all the tests contemplated by the programme. As to these, the conclusions of the Ordnance Board were as follows:

The Bethlehem No. 2 system did not withstand a satisfactory test either as regards the carriage or the breech mechanism of the gun. The recoil system failed repeatedly to operate properly, and the defect of axle traverse was conclusively shown, aside from other objections, when traversing was prevented by a slight bending of the axle in firings from rock platform. In general, also, this system lacked sufficient steadiness under fire, the jump of the wheels is excessive, and it could not be served by cannoneers sitting upon the trail. The breech mechanism proved defective in the form of the thread, which permits the block to be easily wedged in its seat, and the carrier latch worked with difficulty when dusted. The link connecting the operating lever and breechblock was broken and the lever handle also. A further serious objection is the method of assembling the firing pin and spring by which a prohibitive length of time is required to replace one of these parts in case of breakage.

The Ehrhardt material is the only one of the whole number tested in which the total weight allowed behind horses (cannoneers excepted) falls within the limit of 3,950 pounds prescribed by the programme. The performance of this material, on the whole, including ammunition with time fuse, proved very creditable. Few occasions arose in which any stoppage of fire was required, and the repairs necessitated were such as could be readily and quickly made at the gun, with the exception of repairing the elevating screw and replacing the separators in the counter-recoil spring column.

The Ordnance Department long-recoil material gives a weight of 4,289 pounds behind the horses, and the wheels (diameter 48 inches) are too low. These disadvantages led to a relatively poor showing in the road trials of the field tests. The

performance of this material on the firing grounds was good throughout and marked by fewer interruptions of fire and less need of repairs than any other. On the few occasions when it has failed to return fully into battery it was corrected by slightly releasing the glands of the stuffing boxes, except at one time in the field tests when scoring occurred in the counter-recoil buffers and rendered their removal necessary for cleaning and smoothing off. This scoring was due to small chips of steel which had apparently been inadvertently left in the buffer at manufacture. The steadiness of the carriage in the firing is superior to that of the Ehrhardt, while the latter gave somewhat less carriage recoil, due to the greater surface of the trail spade. The Ehrhardt spade also presents the better form in being pointed instead of having a straight bottom edge.

* * * Where fixed ammunition is used for the interrupted screw mechanism, the firing pin should be eccentric and brought opposite the primer only when the block is locked.

Provided this modification is made the Gerdom breech mechanism can be considered decidedly superior to the Nordenfelt.

The three limbers fitted with springs were all broken down in the tests, and one of them only was carried through the test, after modification, with springs badly damaged. The results of these tests show that the ammunition was not damaged by a test that broke down the spring constructions, and that the latter could not be made to withstand the test without increasing their stiffness to such a degree as nearly to preclude any utility as springs and at the same time add largely to the weight of the material.

23. It is observed that only two systems, the Ehrhardt and the Ordnance Department long-recoil, are reported to have passed the tests in a manner not unsatisfactory. As to these, certain defects and undesirable features are noted by the board.

24. The Department is now proceeding with the manufacture of field material from designs which it has prepared concurrently with the development of knowledge by the tests. The new gun will have a caliber of 3 inches and will fire a projectile weighing 15 pounds with an initial velocity of 1,700 feet per second. The breech mechanism will be of the type used with the Ordnance Department gun in the tests, with a modification for insuring greater safety. The piece will have a recoil of from 45 to 48 inches upon the carriage and the recoil-checking device will be a single cylinder placed under the gun, the return to the firing position being effected by a spiral spring. The gun will be given a slight movement in azimuth upon the carriage about a vertical pivot. The trail and its method of attachment to the axle will be substantially as in the Ordnance Department design tested, but the trail will have greater length to compensate for the increased height of gun necessitated by the substitution of the single recoil cylinder for the pair previously used. The wheels will be of the pattern of the test carriage of the Ordnance Department, but of larger diameter. Bullet-proof shields will be provided.

25. The development of the field material entered for the tests by this Department is perhaps its most satisfactory piece of work for the year. The credit is principally due to Capt. Charles B. Wheeler,

Ordnance Department, who is responsible for the design of the gun carriage.

26. Other classes of field material than that mentioned are necessary for the equipment of the service. As to these the Department is concerning itself with the provision of new designs, but with slower progress than would be desirable, because of the lack of personnel disposable for assignment to the study of the subject.

MOUNTAIN ARTILLERY.

27. Several mountain guns and carriages have been tested by the Department during the year, but none have shown themselves superior to those of the Vickers-Maxim system now in the service, and the manufacture of these is being continued. Should the obligations of the United States for protective duty carry its forces into the countries to the southward of us, where mountainous regions and the absence of practicable roads prevail, this class of gun will be necessary as the main reliance of the artillery.

SIEGE ARTILLERY.

28. A new carriage for the 7-inch howitzer has been built and tested. It differs from the former design principally in having the piece mounted at a height of 5 feet, instead of 6 feet above the ground; this for the purpose of increasing the stability when upon the march. The carriage has been tested with satisfactory results, showing that it fulfills the object of its design, and it is being reproduced in limited quantities. It is, however, recognized that improvements of siege material have necessitated the rearmament of the service with this class of weapon and the Department is engaged on new designs therefor; but being hampered by lack of officers it has not been able to carry on simultaneously the designs for different pieces and carriages of the class, some of which are therefore awaiting the opportunity to take them up.

29. Experiments are in progress at the Sandy Hook Proving Ground having for their object the determination of a design for large capacity shells for siege pieces, to be used with high explosive bursting charge.

SEACOAST CARRIAGES.

30. The rate of delivery and issue to the service of seacoast carriages completed during the year has in general been satisfactory. In addition to the manufacture of a limited number at Watertown Arsenal, contracts required the delivery of carriages by two private manufacturers, as follows:

Six-pounder and 15-pounder guns, carriages, and ammunition by the Driggs-Seabury Gun and Ammunition Company, and

Ten-inch and 12-inch disappearing carriages by The Midvale Steel Company.

31. The appropriation for the construction of material by the Driggs-Seabury Gun and Ammunition Company, under their contract with this Department, dated April 15, 1898, lapsed June 30, 1901, and in consequence no deliveries of new materials thereunder were made during the past year. The balance of the material undelivered under this contract is as follows:

12 15-pounder guns and masking parapet mounts.
2 15-pounder guns and casemate mounts.
12,000 rounds 15-pounder ammunition, steel shell, complete.
6,973 rounds 15-pounder ammunition, common shell, complete.
4,000 rounds 15-pounder shrapnel, complete.
2,000 rounds 6-pounder ammunition, steel shell, complete.
1,000 rounds 6-pounder ammunition, common shell, complete.

Authority to resume work on this contract has recently been given as a result of Congressional action, and there appears to be no reason to doubt the ability of the contractors to meet the terms of the renewal.

32. The company has also been much delayed in its work under a contract for similar material, dated July 8, 1899.

33. In May, 1901, the works at Derby were closed and remained so, pending a reorganization of the company, until October 1, 1901. A supplemental contract of the latter date was made necessary by the failure of the company to make deliveries in accordance with the original contract, and simply established new dates and rates for delivery of the remaining material, in consideration of the addition of certain improvements to be made without increased cost to the United States.

34. Deliveries under the supplemental contract were generally on time up to and including February, 1902.

35. During the greater part of March last the works were closed on account of financial difficulties, which resulted in the company going into the hands of receivers, by whom the business has since been conducted.

36. The Midvale Steel Company was not able to deliver the carriages under its contract of August 2 and 20, 1900, within the stipulated time. The delays in the delivery of these carriages were to a large extent due to an underestimation by the company of the time required to establish a new industry in its shops, including the installation of plant and the providing of the various materials requisite for the successful prosecution of the work. Now, however, the company has this department well organized and equipped, and all present and future contracts should be completed in contract time, due allowance being made for delays caused by improvements made as the work progresses.

37. The attention of the Department has been directed toward

improving the designs of seacoast carriages, particularly with reference to their method of control, facility of loading, and ease of maintenance in good order.

38. The disappearing carriages, model of 1901, embody all of the desirable improvements indicated by experience and practice had with carriages up to the present time, including the application of a system of electrical control in connection with an improved method of sighting.

39. The electrical equipment applied to the 12-inch disappearing carriage exhibited at the Pan-American Exposition, while imperfect, attracted favorable attention from visiting officers.

40. To increase this experience and to test further the advantages of such equipment, orders were placed for the attachment to eight 12-inch disappearing carriages, at four widely separated forts, of two systems of electrical control devised by different manufacturing firms.

41. Tests have been made of the apparatus supplied, and these and other experiments made during the past two years have proved conclusively the desirability of attaching electric motors to disappearing carriages in service, for retracting the guns at least, and an estimate to cover the cost of their application to all 12-inch carriages has been submitted.

42. In addition to the improvements in carriages efforts are being made to increase the rapidity of fire from all seacoast guns by the application of automatic or semiautomatic appliances for opening and closing breech mechanisms and by the use of special devices for ramming projectiles and inserting powder charges. By these means it is hoped that the present rate of fire will be considerably increased.

43. The subject of the continuation of the production of disappearing carriages for use in the coast-defense service has received prominent consideration during the past year. Meeting the demand for them, the manufacture of these carriages was commenced in the year 1893, after a thorough test of types, and continued without interruption until the present year. The efficiency of the type used was never called in question until the Commanding General of the Army, in letters dated October 14, 1899, and April 26, 1900, reported the system as being complicated, expensive, uncertain, and unnecessary. This was followed by action by the Board of Ordnance and Fortification, of October 8, 1900, the board by a majority vote, as then constituted, recommending that no additional disappearing carriages be manufactured for use on high or medium sites and that no more should be manufactured for use on low sites until the proportion of those to be placed on such sites should have been reduced to one-third of the total number to be so located. This action never having received the approval of the Secretary of War, the manufacture was continued until Congress at its last session directed that the further production of the carriages should be contingent upon the thorough

test of the system by a board of disinterested officers, including also a civilian mechanical engineer.

44. A board was therefore appointed consisting of an officer of engineers, an officer of ordnance, a naval officer, three artillery officers, and a civilian mechanical engineer, and was directed to test the system by firing not only the thirty rounds from a 10-inch disappearing gun prescribed by Congress, but also thirty rounds from a 10-inch barbette gun and ten rounds each from 6, 8, 10, and 12 inch guns mounted on both disappearing and barbette carriages. The board visited five artillery posts and fired over 150 rounds with full service charges, and in conclusion recorded its opinion that the general mechanical principles involved in the chief elements and movements of the Buffington-Crozier disappearing carriage were admirably adapted to their purpose.

45. The long-continued firing of some of the guns used in the test at a more rapid rate than has ever before been attained, as far as the information of this Department extends, disclosed the fact that the material of the gas-check pads used is considerably and unfavorably affected by the resultant heat, and indicated the necessity for modifying the pad in such manner as to meet this difficulty. The attempt is being made by the alteration of the form and composition of the gas-check pad and by subjecting it to much heavier initial compression. Success is hoped for. The incident illustrates the desirability of occasional long-continued tests of the material under service conditions; the hesitancy to incur the expense entailed by such tests should give way to the necessity for certain knowledge as to the endurance of all the elements of the armament.

SUBCALIBER TUBES.

46. All the field batteries in service, with the exception of one, have been supplied with caliber .30 tubes and ammunition for subcaliber practice, and also the two batteries of siege guns.

47. For the mountain guns a combined dummy and drill cartridge has been provided and supplied to all except two of the batteries.

48. These tubes are issued on the basis of one caliber .30 tube for each siege gun and three to each field battery of six guns. One combination dummy and drill cartridge is issued to each mountain gun.

49. One-pounder subcaliber tubes have been provided for all guns from 4 to 12 inches caliber and combination drill and dummy cartridges caliber .30, for the 6 and 15 pounder guns.

50. Two hundred and fifteen of these 1-pounder subcaliber tubes have been ordered by contract from the American Ordnance Company. All the tubes for the 8, 10, and 12 inch breech-loading rifles have been completed. Those for the rapid-fire guns are not finished, but their completion is expected at an early date.

51. These tubes are to be distributed one tube per post for each caliber and model. Ninety-two tubes, which comprise all now required for the 8, 10, and 12 inch breech-loading rifles, have been ordered issued, and shipment awaits only delivery of special packing boxes.

52. Of the 92 ordered issued 20 are for the Pacific coast, which will complete the equipment for that coast. The remainder are to be distributed in the Department of the East.

53. For subcaliber practice with the 12-inch breech-loading mortars 2.95-inch tubes will be used, and experiments on this subject are now in progress.

54. The annual allowance of ammunition for this subcaliber practice is as follows:

For mountain, field, and siege guns, 500 rounds caliber .30 ammunition per gun.

For 6 and 15 pounder rapid-fire guns, 2,000 rounds caliber .30 ammunition per company.

For all other rapid-fire guns, 1,000 rounds 1-pounder ammunition per company.

For 8, 10, and 12 inch breech-loading rifles, 300 rounds 1-pounder ammunition per company.

ARMY AND NAVY MANEUVERS.

55. At the joint maneuvers which took place in the latter part of September in the New London and Narragansett artillery districts a number of matters connected with the coast defense were given such prominence as to arrest thought, and thus to constitute practical lessons as to necessary improvements and additions. The shipment of ammunition required for target practice by the companies forming the garrisons of the posts and by those which were ordered to them for participation in the maneuvers, of that required for use in the blank firing during the progress of the maneuvers, and of the reserve ammunition which it is contemplated to keep at the posts was commenced about one month previous to the date of the beginning of the exercises. It was made apparent that this time was not sufficient for the supply, by ordinary means of transportation, of such a large quantity of powder and projectiles as was required. The shipping facilities of the powder depot near Dover, N. J., and of the ordinary means of transportation were overtaxed, with the result that it may be considered demonstrated that special means will have to be taken whenever in future shipments of equal magnitude may be again required, and that the enlarged facilities now in process of establishment at the powder depot are of imperative necessity.

56. A number of guns and mortars were hastily mounted and prepared for use, so that practically all of the emplacements were provided with their proper armament. Those pieces which had not before

been fired from their emplacements were given proof rounds in order to test their condition and serviceability. As a result of these proof rounds, a fact of which there had recently been some evidence was developed, viz, that the racers of the mortar carriages were too weak to withstand the recoil resulting from the full charge of smokeless powder developing the highest velocity which the mortars had been found capable of giving to the projectile. The use of these highest charges will therefore not be made until after the racers of the carriages shall have been replaced by similar ones of cast steel, until which time the extreme range must be limited to 11,500 yards, instead of the 12,500, of which the pieces are capable; but as this is some 1,500 yards greater than they were originally designed to attain, the change may be regarded as one giving, at small expense, a considerable increase over the primitive value of the mortars.

57. The large amount of target practice which immediately preceded the maneuvers proper constituted a severe test of the armament. In addition to the ammunition for this target practice a special allowance for the purpose of more thoroughly testing the material was made, all of it consisting of full charges of smokeless powder and projectiles of standard weight. The whole constituted a test such as none of the seacoast material of the country has ever before been subjected to; special instances of the strain which the material endured may be mentioned in the firing of more than 40 rounds from each of the 6-inch disappearing guns at Fort Wright, and, adding the rounds incident to the maneuvers to the series which had been fired immediately before by the carriage-testing board, the firing of over 100 rounds, 80 with full service charges, from a 10-inch disappearing gun. These large number of rounds developed no weakness of the guns except that previously mentioned of the gas-check pads, which new difficulty, of the class which it is the object of such operations to bring out, is being met by methods already described. The gun carriages survived the test without the least symptom of weakness, and at the conclusion were in perfect condition for an indefinite continuance of their service.

58. Some of the 15-pounder guns exhibited an imperfection of performance which was anticipated. These guns and their mounts were obtained under contract from private manufacturers, and after their construction was well advanced it was discovered that the cradles of the mounts were not well designed, and owing to weakness of form were distorted by the strains due to the recoil of the pieces, causing binding of the parts. The replacement of the cradles is in progress and has been accomplished with some of the guns of the armament of the maneuver district, which operated without difficulty. Those which gave trouble were all nursed through their proper number of rounds, but at a diminished rate of firing.

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59. The experience with this material illustrates a class of difficulty which is encountered by the Department. The maintenance of an establishment for the designing and construction of ordnance is an enterprise of great magnitude, and it is doubtful if the patronage of this Government alone is sufficient to support an establishment with the proper plant and employing workmen of necessary skill, as well as the very expensive designing staff required to produce constructions of this special class, for which there is no commercial demand. The quality of the material and workmanship entering the armament which is purchased from private manufacturers may be insured by careful inspection, but some unfortunate experiences of this Department indicate that disappointment and derangement of its plans, as well as great delay, may be expected as the result of effort to utilize in the production of the ordnance which it requires the design of weak organizations not employing engineering personnel of first-class ability.

60. The performance of 6-pounder guns mounted upon rampart carriages designed for use both behind parapets and as field pieces in the open, while demonstrating the serviceability of these weapons, was not of that character of satisfactory efficiency which this Department likes to consider a characteristic of its material. The mounts for these guns are compromises designed to fulfill two objects, and the criticism to which they have been subjected, resulting finally in the determination to build no more of them, illustrates the uselessness of the attempt to use in our service any material in the production of which economy may have been promoted at the expense of efficiency. Every such effort is opposed by a voice which makes itself effectively heard, with the result that the true policy is shown to be the embodiment in material furnished of the highest degree of efficiency which can be attained, and the meeting of considerations of forced economy by diminished quantity.

61. Indications of previous experience were continued during the maneuvers to the effect that the effort to provide the necessary mechanical skill for the care of the armament through the instrumentality of the two mechanics now provided for by law for each company of artillery is not a success. Company commanders have repeatedly stated that they had not in their companies men of sufficient skill to be intrusted with the execution of the most ordinary work of a machinist, and my own observation during these maneuvers was that the processes which constitute the daily work of one in charge of any machine had necessarily to be attended to by the mechanics of the Ordnance Department. The reason seems to be the insufficient pay of the company mechanics, which does not tempt men who can secure the wages of machinists in private employment. This is corroborated by applications which have been made by exceptional ones of these company mechanics to secure their discharge from the service in order that they might work at the armament in the employ

of this Department, for the sake of the higher pay. In order to meet this condition and to provide the officers of artillery with proper help in caring for the armament of the fortifications it is considered that the pay of these mechanics should be considerably increased, reducing, if necessary in order to meet the increased expense, their number from two to one per company.

62. It is also thought that the personnel of each artillery post should include a machinist sergeant, with pay, etc., the same as that of the electrician sergeants now provided for. Men of the class of these sergeants will be absolutely necessary for taking proper charge of the small repair shops which are now being set up by this Department at the headquarters of each artillery district. They could be advantageously enlisted by the Ordnance Department from among the workmen of known qualifications employed at its various manufacturing establishments.

63. During the maneuvers the temporary garrison of Fort Rodman, Mass., consisted of a battalion of the First Regiment of Massachusetts Artillery. The personnel of this regiment is composed largely of engineers, machinists, and electricians, who bring to their duties very valuable knowledge of mechanical details, and who, starting with this extremely desirable equipment, and having to learn only the military duties of a garrison soldier, are believed to be capable of being quickly transformed upon occasion into an effectual addition to the peace-time garrisons of the fortifications.

64. The expense to this Department of the maneuvers has not been great. The total value of the powder shipped to all the posts for use in blank charges is $5,963, and this has not all been expended; its use can in future be regulated so as to considerably diminish the quantity required without any loss of beneficial effect. The cost of the special allowance of ammunition made for more thoroughly testing the material was $30,710.32. This, having accomplished its object, need not be again made to the posts of the two districts involved; while the cost of the ammunition allowed the companies for target practice, being a regular allowance, can not be considered an extra expenditure. The expense is considered to be small in comparison with the value of the opportunity afforded the officers of the Department for association with officers of other branches of the service, both in the Army and Navy, in an effort in which all are so much interested, and with the advancement of the efficiency of the defenses, which would not have been attained without the impetus of the maneuvers.

PERSONNEL.

65. Existing law contemplates that vacancies in the Ordnance Department shall be filled by the detail of line officers of the same grade, who shall serve in the Ordnance Department for four years,

and if below the grade of lieutenant-colonel shall not be again eligible for such detail until they shall have served for two years in the line. The law provides that the details shall be made under such system of examination as the President may from time to time prescribe. Since the passage of the act of February 2, 1901, there have been fifteen vacancies in the grade of first lieutenant in the Ordnance Department, and for these there have been six applicants. Recognizing that it was not the intention to reduce the efficiency of the Ordnance Department or to lower the standard of attainment of its officers, the character of the examination to which officers have been subjected as a preliminary to detail for duty therein has not been changed from that which obtained prior to the passage of the above-mentioned act. This examination three of the applicants have passed. These officers have been performing duty in the Department since June last. There remain twelve vacancies, for which there are no applicants. The inference is that the inducement of such service is not sufficient to tempt officers to prepare themselves for or to undergo the examination which is required. Under the laws in force previous to the passage of the act of February 2, 1901, second lieutenants of the line were eligible for transfer to the Ordnance Department upon the occurrence of a vacancy, and by such transfers they secured both a permanent appointment and an advance to the grade of first lieutenant. With these inducements there was no difficulty in securing candidates capable of passing the examination, the numbers being, in ordinary times, sufficient to produce competition, though in times of prospect of rapid promotion in the line and of small opportunity for preparation for examination the rate of application was so slow as to cause vacancies to stand for considerable intervals.

66. In order to supply officers for the urgent needs of the Ordnance Department three courses appear open for trial: the standard may be lowered; the details may be made arbitrarily; or the inducements may be increased.

67. To lower the standard would be to abandon the position which has been held since the formation of the Department—that special aptitude and technical skill are required in the establishment and production of the weapons which the Army is to use in war. These requirements, which have been always recognized, have become increasingly prominent during the advance of this mechanical age, no characteristic of which has been more pronounced than the complete entry of its spirit into the production of implements and engines of war. War is competition; there is in it no standard of excellence for anything; it does not suffice to have good material, good soldiers, and good officers, if the enemy has better material, better soldiers, and better officers. The designer and constructor of ordnance must be a mechanical engineer, capable of computing the stresses brought upon

the parts of complicated structures by the control of masses set in motion by the action of immense forces, which he must be able to estimate; he must master the methods of arranging and proportioning the parts of the structures so that they may withstand the forces of which he shall have previously determined the magnitude, and he must be familiar with the processes of the constructive arts which are concerned with the fabrication of his machines, in order that he may take full advantage of their possibilities and may not produce impracticable designs requiring the impossible. He must understand chemistry, whose science enters so intimately into the composition and action of explosives, his main source of supply of primary power, and into the art of metallurgy which supplies him with his usual material for utilizing and controlling the power. He must be equipped with the knowledge of the electrical engineer, that he may deal with the power which is finding increasing application in the operation of ordnance constructions and of the plants for producing them. His knowledge of these subjects must not be merely that of the liberally educated man understanding the general principles of all professions, but that of the expert with details at his finger ends, in order that he may bring it effectively to bear upon problems which are continually before him. The necessity for the technical expert in the profession of the mechanical engineer is greater than in any other branch of the engineering profession, because of the closer relation therein between theory and practice; and among mechanical engineers the designer and constructor of ordnance must have especially sound mastery of principles, as he must oftentimes deduce the methods of their application to his art without the aid of the many handbooks and practical treatises which are so useful in the commercial practice of the profession. If it be asserted that no great proportion of ordnance officers have in the past been of the character which is described, the answer is that such fact would afford reason for raising the standard and not for accentuating an undesirable and dangerous condition by lowering it. Whatever excellence of material the service is blessed with is due to the presence among the officers of the Department charged with its provision of individuals whose qualities approach the standard which is asserted to be proper.

68. If, recognizing the necessity for the provision of the fighting tools to be confided to a body composed of officers of special attainments, it should be attempted to secure the component individuals by a process of detail in which the wish of the officer would not be initiative or be consulted, it would have to be decided whether the officers picked out should be ordered for examination or should be detailed without examination. If the former, it would seem that the prospect would not be fair of obtaining officers able to pass a difficult examination which they had not wished to undergo, for which they had not prepared, and leading to duty which they had not sought. If

the details should be made without examination, all the discrimination furnished by the latter would be lost, as would also be the case if the examinations were not difficult. The experience of over twenty-five years has shown that there are always among the lieutenants of the line officers capable of taking the examinations corresponding to the established standard, and always, also, enough of these to provide, among a number up to the requirements, appointees of the excellence of successful competitors. To detail officers without examination would not only cause the loss of the certain guarantee of standard attainment and of all the additional superiority resulting from competition, but would place in positions requiring the closest application and the intense interest of the devotee, officers having problematical liking for the work, and without the stimulus indispensable for the successful pursuit of the engineering profession. It would also eliminate the very useful general review of student courses which the preparation for examination entails, and for which there is no time after entering upon the duties of the Department. It would seem to undoubtedly lower the standard.

69. There remains the third alternative mentioned above, viz, that of increasing the inducements presented to lieutenants of the line for service in the Ordnance Department. This can be done by permitting the attainment of a temporary advance of one grade by such service and by providing for greater permanence of duty in the Ordnance Department, so that such duty may become practically the life work of the officer. It is recognized that efficiency as an ordnance officer will be increased by occasional service with the troops who handle the product of the Ordnance Department, but the principle should be followed of regarding such service as an incident of the practice of the profession of the ordnance engineer, rather than to attempt such practice as an incident of service in the line; there would thus be no assault upon the detail system, of which the advantages are well perceived, but its regulation in such manner as to really accomplish its object of benefiting both the Department and the line. It should also be noted that no increase of expense would be entailed by making lower officers eligible for details to the grades in the Ordnance Department, as the number of these latter grades would not thereby be increased, and the total cost of the Department and of the entire Army would remain the same. By permitting the detail of second lieutenants for duty in the grade of first lieutenant in the Ordnance Department another very desirable object would be accomplished, viz, that of commencing the technical education of the officer at a youthful age. Under present conditions promotion in the Army is going to be exceedingly slow, and officers will spend a very considerable number of years in the grade of second lieutenant, not being eligible, under present law, for detail in the Ord-

nance Department until they shall have reached the grade of first lieutenant, and they will have had a long time in which to forget the scientific foundations of technical education which they may have acquired at the Military Academy or at other institutions of learning, also they will have passed the age at which young men embark with enthusiasm and zeal upon the study of a new profession.

70. In considering whether it is worth while to offer inducements for service in the Ordnance Department it must be borne in mind that its technical duties are not learned in the line, as are most of those pertaining to some other of the staff departments of the Army, and that special and laborious preparation for entry into the Department and close work, of a nature not attractive to one without special aptitude, are necessary, and do not tempt officers from a life which, if not less laborious, certainly offers a more agreeable combination of indoor and outdoor occupation than does that of the technical staff officer. As between the requirements of one or two years' service with the line between details for service in the Ordnance Department, it is certain that the longer period would break up an officer's service to an extent greater than is evident without weighing the effect which is produced by the second rolling around of each season of the year in turning the officer's ideas into a different channel and dimming the impression of what he has learned of technical methods.

71. Progressive development of ordnance material requires strenuous prying, with stimulated imagination, in advance of the known. It is a fact which must be admitted that there has not been in the past enough original scientific investigation upon subjects connected with the advancement of artillery science in the United States. This has been because of the lack of a sufficient number of officers possessing the necessary technical acquirements and because it has been rather the custom to take for granted in a vague sort of way that the designs governing the important structures which it has been necessary to produce have come, like the air we breathe, from some indefinite source with which the practical individual has not had to concern himself. One result of this state of affairs has been the abundant accusation of copying foreign productions, another the charge of being always behind other nations in the armament which has been provided for the service. That these accusations would be likely to become well founded has been recognized, and attentive study has been given to means for remedying the lack of technical knowledge by providing such a system of careful and regular instruction for its officers as has not heretofore existed in the Department. Any such effort would be frustrated by a system depriving the Department of the services of its officers as soon as they should acquire the beginnings of their special education, and giving them such service only under conditions which would prevent all ardor in its pursuit. The universal rule that special

requirements should be accompanied by special inducements finds no exception in the military service.

72. An honest effort has been made to supply the Ordnance Department with proper officers under existing law. The effort has failed, and something else must be tried. The personnel of the arsenals has been reduced to the smallest number of officers which can carry on the administration of the business which is conducted at them, the details of which form the daily work which is imperative and to which that of possibly higher class must yield. As has appeared above, needed designs are not in progress for lack of officers, of whom there should be many more working upon problems of ordnance development. More vacancies will shortly be created in the Department. They can be speedily and advantageously filled by holding out something to the eligible body of officers, which contains abundant talent. This subject has been dealt with at much length because we can not afford to wait for the demonstration—in discovery in the time of need of the inadequacy of material produced during the period of preparation—of the reduced efficiency of the Department charged with the production of the most expensive and the most characteristic of war supplies. There being no immediate penalty for being wrong, either in making poor recommendations or in failure of action upon good ones, that sense of responsibility which recognizes the liability to be called to account is apt to be inactive, and needs the reenforcement of careful discussion.

ACTING ORDNANCE OFFICERS.

73. At each artillery post there is now an acting ordnance officer who is accountable for the ordnance property at the post and makes returns thereof to this office. It is recommended that in place of these officers there be assigned an acting ordnance officer for each artillery district, who should be a member of the staff of the district commander and should be charged with the proper supply and care of all the ordnance material in the district. The ordnance sergeant at each of the posts would have immediate charge of the stores at his post under the authority of the commanding officer, but would make no returns thereof. The effect would be to make the district the unit instead of the fort, and it is believed that the system would keep the district commander in closer touch with ordnance matters in his district and would result in uniformity of equipment and practice at all of the posts. The present unnecessary accumulation of considerable amounts of stores at points where they are not needed and the duplication of supplies at points within easy distance of each other would be avoided, as such stores could be shifted within the district as required for the uses of the district as a whole. It is probable that acting ordnance officers of districts would best be relieved from most other duties during their

incumbency, in order that they might be able to make careful study of all the ordnance requirements for the district, and be constantly on the alert in keeping on hand supplies sufficient in amount and suitable in character and themselves thoroughly informed as to their uses. There might be instances of too wide separation of the posts of an artillery district for the method proposed to be practicable, but it is believed that it would be convenient in most cases and that it would certainly result in reduction of the clerical labor required for correspondence and for the preparation of returns.

ISHAM SHELL.

74. This shell, as is known, is primarily designed as a torpedo shell for the purpose of carrying large charges of sensitive high explosives, and in the form presented is not intended or expected to penetrate armor plate. The special invention embodied in it is the means for firing it safely from a high-power gun with a large charge of powder, without detonating the explosive by the shock of discharge; and the special claim for efficiency, as compared with the explosion against armored structures of much larger charges of explosives, is that such explosives, being of less sensitive character, are not really detonated, while the sensitive high explosive carried by the Isham shell, being surely detonated against the plate, will produce destructive effect notwithstanding its much smaller quantity than that which has been used with other methods tried. Experiments already made with the shell having resulted in some differences of opinion as to its efficiency, the Board of Ordnance and Fortification, in the autumn of last year, made an allotment for firing three of these projectiles from a 12-inch service rifle; one of the shells, the first, to be weighted with sand but without explosive charge and fired into a sand butt with a pressure of not less than 50,000 pounds to the square inch, to test its structural strength; the other two shells to be charged with explosive gelatin and fired, one with a pressure as near as might be to 38,000 pounds to the square inch, and the other with a pressure as near as might be to 45,000 pounds to the square inch; the object of the test being to determine whether or not the board should make an allotment to procure armor plate as a target to test the service efficiency of the shell.

75. The first shell was fired upon May 19 last and was recovered from the butt in fragments of varying size, but it was the opinion of the board that it did not break up before reaching the sand butt. The experiment was considered inconclusive as to the structural strength of the shell, and authority was granted the inventor to construct three additional shells of somewhat greater strength, the first of them to be weighted with sand and fired under the same conditions as the preceding. This shell was fired, as arranged, on August 26 last. Upon recovery it was found to have suffered somewhat from the discharge,

but not sufficiently so to indicate to the inventor inadmissible lack of strength of the remaining shell intended to be charged with the explosive. This is the present status of the experiments with this projectile; the total cost of which to date has been $16,632.78.

MANUFACTURE OF ORDNANCE MATERIAL UNDER CONTRACT.

76. During the fiscal year work has continued at the works of various manufacturing firms under existing contracts for ordnance material, and satisfactory progress has, with exceptions, been made.

77. Among the principal articles delivered under contract during the fiscal year may be mentioned:

3 12-inch B. L. rifles, model 1888, Bethlehem Steel Company.
5 10-inch B. L. rifles, model 1888, Bethlehem Steel Company.
24 5-inch B. L. rifles, model 1897, Bethlehem Steel Company.
8 15-pounder R. F. guns and (masking) parapet mounts, model 1898, Driggs-Seabury Gun and Ammunition Company.
30 6-pounder R. F. guns and parapet mounts (wheeled), model 1898, Driggs-Seabury Gun and Ammunition Company.
6 6-pounder R. F. guns, American Ordnance Company.
8 12-inch disappearing carriages, model 1897, Midvale Steel Company.
4 10-inch disappearing carriages, model 1896, Midvale Steel Company.
22 12-inch mortar carriages, model 1896, Rarig Engineering Company.
2,750,000 pounds steel forgings for cannon of 6 to 16 inch caliber (about equally divided between the Bethlehem and Midvale steel companies).

78. Also a large number of large and small caliber projectiles, fixed metallic ammunition for rapid-fire guns, miscellaneous forgings and castings, and other material. There was also purchased a considerable quantity of smokeless powder, which is reported upon under the appropriate head.

CANNON, SEACOAST GUNS, AMMUNITION, ETC.

79. During the year a number of the new 5 and 6 inch rapid-fire guns have been mounted in the fortifications. The carriages had been installed for some time previously, and the guns themselves were practically completed, but were held to await the addition of an improved form of firing mechanism before mounting them upon their carriages.

80. The normal method of firing all seacoast guns is by electricity, but in case of a breakdown in the electrical connections means must be provided for firing by percussion or friction, the former being the usual alternative. For this purpose either two separate primers, one for electrical and the other for percussion firing, are used, or else a single primer in which both electric and percussion elements are combined. The Department decided, however, after considerable investigation and study of the matter, that a combination electric-friction primer offered a greater guarantee for safety than the combined

electric-percussion primer. Accordingly a primer of this description was constructed and a firing mechanism devised adapted thereto, with suitable safety features to prevent the premature discharge of the piece before the breech was fully closed, and arranged to readily eject the primer from its seat in the breechblock after firing or whenever desired. This firing mechanism, being of novel design, naturally underwent considerable modification and development before it passed a satisfactory test, which consumed a great deal of time. It has, however, been tested in service, in recent target practice, and during the maneuvers, and has given a fairly satisfactory account of itself, although some further modification has been indicated as desirable and will be made. The same type of firing mechanism will also be applied to the heavy seacoast guns, mainly with the object of facilitating insertion and ejection of the primer and thus doing away with the present form of screw primer, the insertion and removal of which from the gun are slow operations.

81. The guns of model 1900, both rapid-fire and seacoast guns of large caliber, have an enlarged powder chamber and an increased length of bore, with the object of obtaining a considerable increase in the power of the guns, to keep pace with the improvements made in the quality of armor plate.

82. The question of streaks in gun metal has occupied the attention of the Department for some time, and investigations are being made to ascertain the gravity of these defects as respects the quality of the steel. Owing to the higher qualities of nickel steel it is quite probable that this metal, now used for field and other guns of smaller calibers, where lightness is a consideration, will also be adopted for guns of large caliber. Nickel steel may not be free from streaks, but its higher elastic qualities and toughness should insure greater safety in its use than with the ordinary steel, even where streaks are present. The cost of nickel steel is somewhat higher than the ordinary steel, mainly on account of the high price of nickel, but it is believed that in manufacture the cost per pound of large forgings will not exceed by 3 or 4 cents the price now paid for gun steel without nickel.

83. The question of automatic and semiautomatic breech action is under consideration, and several types have been procured, or are under manufacture, for trial, with a view to demonstrating their advantages in respect to increased rapidity of fire, facility of operation, and durability. As a further step in the direction of increasing rapidity of fire, methods of power loading are under consideration.

84. Contracts have been awarded for a considerable supply of the new explosives for filling shell which have given such satisfactory results in firing against heavy armor plates, the results having demonstrated that it is practicable to fire the new explosive through a hardened plate of 12 inches thickness without exploding the charge until

after the plate has been entirely perforated; in other words, that the charge of explosive in the projectile can be detonated within a ship's body after penetrating its armor. A large supply of detonating fuses, used for exploding the charge of high explosives, has also been placed under manufacture at the Frankford Arsenal, where these fuses were designed. The success obtained with these high-explosive projectiles has led to some modification in the design cf armor-piercing shot, by which their capacity for bursting charge has been largely increased, in fact nearly doubled, without reduction of the power to penetrate armor.

85. The manufacture of smokeless powder is now being successfully prosecuted at four private establishments, and the Department has accumulated a considerable reserve supply. Nothing has occurred thus far to discredit the type of powder now being supplied by the Department, but experience indicates the necessity for careful supervision in the manufacture and frequent inspection and test of the powder in store.

86. With regard to seacoast mortars, the firings made at Fort Preble, Portland Harbor, last spring, have demonstrated the efficiency of these pieces, not only against fixed but against moving targets, and fully justify their employment in the armament of the coast defenses. There have been issued for the seacoast defenses during the fiscal year ended June 30, 1902:

12-inch B. L. R	10
10-inch B. L. R	3
12-inch mortars, steel	49
6-inch R. F. (Ordnance Department)	26
5-inch R. F. (Ordnance Department)	14
15-pounder R. F	10
6 pounder R. F	44
Total	156

87. As to the general condition of the seacoast defenses the statement can be made that the heavy armament, though not complete, is in a satisfactory state of advancement, and that its status is such as to warrant a change in the distribution of the national energy, represented by appropriations of Congress, which has, up to the present, prevailed. A greater proportion than in the past should be devoted to the practice which is necessary to produce skill and familiarity of the personnel with the material, and a less proportion to new installation. It goes without saying that the final duty of the artillerist is to hit the mark, but antecedent to this is the ability to handle his weapons, without which he can not even shoot, and maintain an action. The best practice, both for producing familiarity with the mechanism and accuracy of fire, is that with full service charges, but for a proper number of these the appropriations have always been insufficient; with

the result that there has been natural differences of opinion between those whose eyes have been directed upon the target and those who have been concerned as to the proper working of the mechanism as to the manner in which the funds available should be applied, whether in giving a smaller number of full charges and exact service conditions, or a larger number (three or four times as many) of reduced charges and more practice. Under present orders a certain number of full charges and a larger number of reduced charges are prescribed for each company. It is hoped that larger appropriations will cause the question to disappear.

88. The rapid-fire armament is not so well advanced as the heavier, and no diminution of effort is advisable in pushing this element of the defenses. The mobile artillery, that designed for use in connection with the operations of armies and consisting of field, siege, and mountain guns, is now in the most backward state of all of the national armament. In regard to the standard field material the period of design and experiment has been passed; the actual work of construction is just beginning; the funds on hand are enough for a fair start, but they should be immediately supplemented sufficiently to permit a large increase in the rate of production as soon as the manufacture is well under way. In regard to siege material even as satisfactory condition as this does not obtain; the present armament is fairly efficient, but very considerable improvements are in sight, and should be in process of embodiment.

89. Of small arms and equipments the manufacturing facilities are either in a rationally satisfactory condition of capacity or are in process of such augmentation as will soon render them so.

MAINTENANCE AND CARE OF THE ARMAMENT OF FORTIFICATIONS.

90. To facilitate the maintenance and care of the armament, the seacoast of the country is divided into four districts, containing as nearly as practicable equal amounts of armament. Each district is in charge of an ordnance officer with whom, under present regulations, a post ordnance officer may correspond directly concerning work needed on the armament, thus avoiding the annoying delays incident to the forwarding of all such correspondence to this office through the various military channels. The result of this system has been to relieve this office of a large amount of correspondence and to bring the Department into closer touch with the artillery service by having an officer in direct communication with each limited district who by a sufficient number of personal inspections of his district becomes familiar with its needs.

91. As a part of this system it is also planned to install at one or more posts in each artillery district a small machine shop, in which many of the repairs now requiring shipment of parts to an arsenal can be made.

92. It is thought the saving in time and money by this over the old method will be fully appreciated. Up to the present time the results of this system have been sufficiently satisfactory to warrant its extension in a modified way to embrace the field and siege artillery.

EXAMINATION AND SETTLEMENT OF PROPERTY RETURNS OF THE ORDNANCE OFFICE.

93. The following tabular statement exhibits the condition of the work at present in this division of the Ordnance Office and the amount of work done during the fiscal year:

	Arsenals and inspectors.	Regular Army.	Volunteer Army.	Spanish war volunteers.	Total.
Number of returns not closed June 30, 1901	61	4,666	479	49	5,255
Number of returns received during year	58	9,462	697	49	10,266
Total	119	14,128	1,176	98	15,521
Acted on during the year:					
Finally examined	99	10,083	638	60	10,880
Closed	86	10,665	1,053	87	11,891
Number of returns not closed June 30, 1902	33	3,463	123	11	3,630

CONDITION.

Awaiting final examination June 30, 1901	2,666
Awaiting result of correspondence June 30, 1901	2,589
Total	5,255
Awaiting final examination June 30, 1902	2,102
Awaiting result of correspondence June 30, 1902	1,528
Total	3,630

DETAILED STATEMENT.

Closed	11,891
Examined	10,830
Settled by correspondence	1,061
Awaiting result of correspondence June 30, 1901	2,589
Awaiting result of correspondence June 30, 1902	1,528
Awaiting final examination June 30, 1902	2,102
Total	3,630

WATERVLIET ARSENAL.

OUTPUT OF SEACOAST GUN SHOP.

94. *Six-inch rapid-fire guns, model 1897* M1.—Twenty-nine guns of this model which were in progress at the beginning of the year have been finished and shipped to the Sandy Hook Proving Ground. Firing mechanisms adapted to the use of the latest model combination friction and electric primer were provided for each. These firing mechanisms are of the type known as hand ejection of the primer.

95. *Six-inch rapid-fire guns, model 1900.*—Forty-six of this model are well under way, the type gun being almost completed. A model firing mechanism for use with this gun has been manufactured and is now undergoing test at the proving ground.

96. *Ten-inch breech-loading rifles, model 1895* Mɪ.—Satisfactory progress has been made in the work of assembling the 12 guns in hand, but the work on breech mechanisms has not kept pace with the work on the bodies of the guns, as work on 6-inch rapid-fire breech and firing mechanisms and firing mechanisms for 12-inch breech-loading mortars has been given precedence.

97. *Ten-inch breech-loading rifles, model 1900.*—Forgings for 6 of these rifles of this model have recently been received and work has begun upon them.

98. *Ten-inch breech-loading mortar.*—The type mortar was completed early in the year and shipped to Sandy Hook Proving Ground.

99. *Twelve-inch breech-loading rifles, model 1895* Mɪ.—Of the 18 rifles of this model in hand at the beginning of the year, 11 have been completed, and the others will be completed in a few months. The breech mechanisms of all are nearly completed.

100. *Twelve-inch breech-loading rifle, model 1900.*—The type gun of this model is nearly completed, while 11 others are in process of manufacture. Two combination friction and electric firing mechanisms for this rifle have been manufactured and tested, one following the design prepared in the Ordnance Office and one according to a modified design prepared at the arsenal. The latter has been adopted.

101. *Twelve-inch breech-loading mortars, model 1890* Mɪ.—Of the 40 mortars of this model which were in hand at the beginning of the year, 29 are practically completed except firing mechanisms. The other 11 are well under way and will be finished within a few months.

102. Combination friction and electric firing mechanisms for all mortars in service are being prepared, and 55 have already been completed and issued, and within three weeks some thirty or more will be fitted to the spindles and ready for the coming practice season.

103. *Sixteen-inch breech-loading rifle.*—All the operations connected with the manufacture of this gun have been described in Ordnance Construction Notes No. 78. As the trunnion hoop developed a defect before being assembled, the Bethlehem Steel Company requested its return, and a second forging was furnished without extra cost for the new material, but the labor expended on the first hoop was lost, and considerable delay, three or four months, was caused in the completion of the gun, the latter being finally finished June 11, 1902.

104. All the operations on this gun have been carried out very successfully, and the finished dimensions of the bore were within one-half a thousandth of an inch of the prescribed dimensions, where the allowed variation was three thousandths of an inch, and the depth of the rifling throughout agrees with the prescribed depth to within an amount less than can be accurately measured by the star gauge. The gun is now finished and is awaiting the strengthening of the wharf to enable landing it at Sandy Hook for test.

105. Besides this regular work there have been manufactured combination friction and electric firing mechanisms for—

30 6-inch rapid-fire guns,
32 5-inch rapid-fire guns, and
55 12-inch breech-loading mortars.

106. The breech mechanisms of 27 Hotchkiss 2-pounder mountain guns have been altered from friction to percussion firings, and in addition a number of spare parts for breech mechanisms for seacoast rifles have been manufactured and issued.

107. The amount of work done on small parts during the past year has been large—greater than usual—and the capacity of the shop has been tested to its utmost.

108. The installation of new machinery will, it is thought, relieve the large shops of the greater portion of this work and enable it to be carried out without interfering with the work on the large guns.

SMALL GUN SHOP.

109. Fifty-four 75-millimeter Vickers-Maxim mountain guns are under manufacture. Work on these and on breechblocks, block carriers, and breech mechanisms is in progress.

110. *3.6-inch field mortars.*—Seventeen of these mortars were completed and proved during the year.

111. *Five-inch siege rifles, model 1898.*—Twenty-seven of these were completed and shipped to Sandy Hook Proving Ground. Ten of the model 1898 MII, having the hinge lug forged solid to jacket, are under manufacture and are completed except assembling. The new model Scott sight bracket with quadrant seat is being manufactured for all model 1898 5-inch siege rifles. A new safety device for firing mechanism has been adopted and manufactured.

112. *Seven-inch breech-loading howitzer, model 1898.*—Five of these were completed and sent to the Sandy Hook Proving Ground during the year. The remaining 24 under manufacture are completed except assembling. All howitzers are now provided with quadrant seats on rim base. The firing mechanism has been modified and a new safety device supplied.

113. *Five-inch rapid-fire guns.*—The hand-ejector firing mechanism has been applied to all of these guns. The breech mechanism of the 24 guns manufactured by the Bethlehem Steel Company have been completed here by the addition of the firing mechanism.

114. A large number of spare parts for breech mechanism of field and siege guns are under manufacture. These are all to be turned into store for a reserve supply.

ARM CHESTS.

115. Obsolete armament and implement chests have been modified to contain tools, implements, etc., for both gun and carriage, for the

4.7-inch and 6-inch Armstrong guns, and for the 5-inch and 6-inch rapid-fire guns, and for the 8-inch, 10-inch, and 12-inch breech-loading rifles, and the 12-inch breech-loading mortars.

116. A large number of spare parts for breech mechanism of rapid-fire and seacoast guns are under manufacture. These also are to be turned into store for a reserve supply.

117. Sight holders for disappearing carriages and sight brackets for standards on barbette carriages have been modified by attaching a sight retainer to hold the telescopic sights so that they may be left in place throughout any series of firings.

ADDITIONS AND IMPROVEMENTS TO POST HOSPITAL.

118. The contagious-disease wards in the annex to the hospital are separated and equipped with all modern appliances and the old hospital has been greatly enlarged. The new hospital equipment is most complete, adequate provision being made for operations for accidents of not infrequent occurrence, and the above changes supply a defect existing at this arsenal for many years.

SPRINGFIELD ARMORY.

119. The case-hardening room at the hill shops has been enlarged, in order that new furnaces might be installed to increase its capacity to treat parts for 400 guns per day of eight hours.

120. The fireproof addition to the water shops (257 feet 8 inches by 50 feet), for which an appropriation of $95,598.71 was made, has been completed. The preparation of the foundation for this building was attended with many difficulties. It was not only necessary to extend across the canal three arches, but also to build over made ground, part of which was the original bed of the stream. This necessitated sinking concrete piers, 5 feet by 8 feet, for some distance—some of them to a depth of 36 feet below the level of the ground—to get a solid foundation. The foundation, arches, and pier work were constructed under the special direction of Capt. O. C. Horney, to whom and to Capt. J. T. Thompson, who directed the construction of the superstructure, great credit is due for careful supervision and thorough work.

121. There was appropriated for the purchase of machinery for the hill and water shops $204,119.30, of which amount $49,084.63 has been expended, leaving a balance of $155,034.67 on hand for the purchase of machinery already and yet to be ordered. Contracts have been awarded for most of the machines needed, and as fast as delivered they are being placed in the shops where required.

122. In the new addition at the water shops it is proposed to run the plant by electric motors—four 20-horsepower motors to each floor,

grouping the machines in such a way that the daily output can be increased or decreased by running one or more groups.

123. The new gas heating plant for forging, annealing, etc., has been completed and has worked satisfactorily.

124. There have also been set up at the water shops 16 new furnaces in the forge shop and 6 new annealing furnaces.

125. A recent appropriation of $5,500 will enable us to put in a new penstock and wheel, to run two 100-kilowatt generators—one for each floor—for power and lighting.

126. A new electric-light plant of sufficient capacity to light all the shops has been installed. The old system that formerly lighted a portion of the shops has been altered and utilized for general lighting of quarters, barracks, stables, and of the grounds of the post.

127. *Magazine rifle and carbine.*—In addition to the manufacture of the service rifle and carbine of latest model, and spare parts for them for issue, satisfactory progress has been made with the drawings and fixtures for the new rifle. The order for 5,000 will, it is hoped, be completed early in the coming spring. As the new magazine rifle is chambered differently from the present service rifle, corresponding changes will have to be made in any machine or automatic guns hereafter to be procured. The automatic machine gun at present in use has been fairly satisfactory, but the Department will take advantage of the change in ammunition above referred to to make the necessary experiments to obtain the most reliable automatic machine gun in the market.

128. Authority having been granted, 100 rifles having barrels shortened 4 inches were made and have been issued to get an expression of opinion from the infantry as to the desirability of thus reducing the weight of the rifle. If it should not be too heavy for the cavalry, the manufacture and issue of but one arm for both services might be an advantage. With the issue of this short rifle it is thought that in each company there should be selected sharpshooters to be armed with a longer rifle provided with telescopic sight.

129. *Arms manufactured during the year.*—Twenty thousand magazine carbines, caliber .30, model 1899; 43,246 magazine rifles, caliber .30, model 1898, and 1,056 swords and sabers have been manufactured. A large number of appendages and spare parts have been manufactured and also many arms have been altered and repaired.

130. Subcaliber attachments for 3.2-inch guns, 7-inch howitzers, and 5-inch siege guns have been manufactured.

131. Thirteen thousand nine hundred and fifty-six Colt revolvers of various calibers have been inspected and accepted; also a number of automatic guns, with their carriages and mounts.

132. *Experimental firing.*—In this Department firings have been made for a variety of purposes, the most important being for testing

various rifles and automatic pistols submitted by inventors, sighting of experimental short (26-inch) barrel recently issued, making comparative tests of riflings differing as to twists and number of grooves, determination of a suitable cartridge for gallery practice, and also for the new 2,300 feet per second magazine rifle. These firings have involved determination of accuracy, muzzle velocity, pressure per square inch, and many other incidental tests.

WATERTOWN ARSENAL.

133. The shops of this arsenal have during the year been employed to their full capacity in the manufacture of gun and mortar carriages, shot trucks, projectiles, implements, targets, and parts for the repair, alteration, and improvement of the armament of the seacoast fortifications of the country. It is the central supply station upon which requisition is made directly by district armament officers for such spare or new parts and for such alteration and repair work as can not be conveniently or economically obtained in the vicinity of the fortification concerned.

In addition to these operations pertaining to the country at large this arsenal is specially charged with the repair, alteration, and improvement of the armament in the northern district (i. e., the New England coast, down to and including New London, Conn.), which duties have been satisfactorily performed and have resulted in a high state of efficiency of that armament.

134. The following gun and mortar carriages have been completed during the year:

12-inch disappearing carriages, L. F. model 1897	1
12-inch barbette carriages, model 1892	1
12-inch mortar carriages, model 1896	6
10-inch mortar carriages, model 1900	1
8-inch disappearing carriages, model 1896	3
5-inch barbette proof carriage for Sandy Hook	1
7-inch mortar carriages, with platforms	22

135. The Secretary of War having approved the manufacture of a disappearing carriage for the 16-inch rifle, instructions were given to have the drawings prepared and the manufacture undertaken at this arsenal. The engineering construction of this carriage is in charge of Gen. A. R. Buffington, retired, who approves all drawings before work in accordance with them is executed. Work on the carriage is reported to have progressed satisfactorily.

136. The capacity of the shops has been slightly increased during the year by the installation of a few machines, and greater economy of manufacture has been attained by changing the method of transmitting power from the main machine shop to the extension shop and foundry from wire rope to electricity.

137. The iron castings of the foundry have further improved in character, and the forging of certain bronze castings having proved conclusively of great advantage the practice has been continued.

138. The manufacture of cast-iron projectiles in limited numbers continues to be satisfactory, and the loss always attending the use of the fine grade of iron, especially in smaller castings, shows gratifying decrease. The projectiles for the 16-inch breech-loading rifle are brought to a uniform weight of 2,400 pounds each, the mean variation in weight being 9 ounces, and upon cutting them open they show soundness to the center.

139. The output of the machine shops as to quantity and quality has been satisfactory. The considerable number of men necessary for detached work at the fortifications is, at times, a source of embarrassment, as the class of men necessary for this work is not always readily obtained, and especially for short periods and short terms of employment.

140. The forging shop turns out good work, and there is such an economy in the use of broken armor plate that all fragments of 2 square feet and of thickness above 4 inches which can be sent from the proving ground can be readily utilized.

141. A better system of fire protection is now being installed, thus meeting a necessity which has existed for some time. The new system contemplates the introduction into the shops and detached buildings of a system of standpipes with the necessary hose for each floor, which, in case of fire, can be brought into action before a steam fire engine arrives.

142. Congress has, by appropriating the necessary funds, authorized the construction of new barracks, and the necessary work will be undertaken and completed as early as practicable.

143. The operations of the testing department during the past year are given in detail in the usual report—"Test of metals, etc."—published annually. Many of the investigations made during the past year are of special importance to ordnance and mechanical engineers, and undoubtedly the detailed report of the results of these investigations will be of much interest to manufacturers and designers, civil and military.

144. An investigation into the strength of "streaked" and unstreaked gun forgings was made by means of hydrostatic pressure applied to two hoops for 10-inch rifles prepared by the Bethlehem Steel Company and tested in the presence of a representative of that company. The hoops were turned down to a thickness of wall of 0.50 inch each. One hoop contained numerous short, dark, interrupted lines or seams where the metal appeared to lack continuity, a condition which has received the designation of "streaked metal." The other hoop was free from these lines, and furnished an example of a sound forging so

far as could be visibly ascertained. The hoops were tested to destruction by interior pressure.

145. The unstreaked hoop displayed a tensile strength and elongation in excess of the ordinary tensile specimens representing the physical properties of the same steel, while the streaked hoop showed a deficiency in corresponding properties.

146. The elastic limits under hydrostatic tests coincide with the specimen tests of the material. Each hoop successfully endured a stress just below its elastic limit, repeated five hundred times in each case, without apparent injury. The appearance of the streaks or seams in the metal acquired greater prominence as the test advanced beyond the elastic limit, and eventually the streaked hoop fractured longitudinally, beginning at the principal streak.

147. The main results of the tests were as follows:

	Hoops.	
	Streaked, pounds per square inch.	Unstreaked, pounds per square inch.
Loaded 500 times with	52,000	53,000
Elastic limit	54,000	56,000
Tensile strength	91,051	125,889
Elongation ... per cent	3.92	18.5
Appearance of fracture	Granular.	Granular.

148. The examination of the internal strains in a specially treated tube, heated and quenched at the bore, has been made, and the presence and magnitude ascertained of longitudinal compressive strains in conjunction with tangential compression at the bore.

149. The objects of the test were to ascertain if the internal strains in a thin transverse section taken from a hollow gun forging represent the strains in the intact forging; that is, whether the state of the metal in a detached slice may be accepted as an index of the state of the metal in the forging, having reference to the tangential internal strains introduced by the method of heating and quenching a tube at the bore. Also to obtain data with reference to the magnitude of the accompanying longitudinal strains, and, furthermore, the effect of exposure to higher temperatures in the elimination of strains introduced by heat treatment.

150. The conclusions from the tests were:

(1) The detached slices represent the state of the metal in the intact tube with respect to the direction of the internal strains, and approximately with respect to their magnitude.

(2) The metal at the bore is under a higher degree of initial compression than indicated by the detached slices. In the present tests the difference is 3,000 pounds per square inch, mean compressive stresses in the slices.

(3) Longitudinal strains of compression at the bore are present, which may be taken approximately at three-fourths of the tangential strains. In the present instance the mean results show the longitudinal strains are 78 per cent of the tangential strains.

(4) The ends of the tubes are bell shaped in consequence of the longitudinal compressive strains at the bore.

(5) The state of the metal at the bore, at the ends of the tube, by reason of the bell-shaped form, is under greatly diminished tangential strains.

(6) Annealing eliminates internal strains. The strains which are introduced into the forging by reason of sudden quenching from a moderately high temperature are removed upon exposure to a moderately high temperature when slowly cooled.

(7) The elimination of internal strains was practically completed upon exposure to 1,100° F. About one-half the primitive strains remained after exposure to 700° or 800° F.

(8) This relief of internal strains is accomplished without material relative movement of the parts of the forging. That is, the reacting parts which were under opposite kinds of strains, tensile and compressive, maintain their dimensions and relative positions after annealing, unchanged.

151. In the line of work on general engineering subjects, investigative tests on the properties of natural and Portland cements have been continued. There were tests on suspension rods from the Brooklyn Bridge, including the examination of some of the rods which were discovered fractured in the bridge in July, 1901, and other rods from the adjacent parts of the structure. The progressive character of the fractures was shown, and incipient cracks found in the adjacent rods.

152. The tests on repeated alternate stresses appear to have demonstrated that some grades of steel have a limit of practically indefinite endurance under fiber stresses in the vicinity of 40,000 pounds per square inch, although the stress is a close approach to the maximum, and a further advance of load soon ends in rupture.

FRANKFORD ARSENAL.

153. *Artillery cartridge plant, carpenter shop, and storehouse.*—For the reasons explained in the last annual report, the three buildings comprising the factory for artillery metallic ammunition, the new carpenter shop, and the storehouse for factory supplies, have been combined under one roof.

154. *Power plant, box making and packing shop.*—Congress during its last session made an appropriation of $58,000 for a power plant for this arsenal and for the removal thereto of engines and boilers on hand, also $28,000 for a box making and packing shop for the small-arms cartridge factory.

155. It is proposed to erect just in the rear of the artillery cartridge factory a suitable power house, with boiler house and coal-storage bin complete, and install therein all serviceable boilers and engines on hand, together with such additions to the power plant as may be found necessary. In this way the four distinct power plants, now located at different points of the arsenal, will be concentrated in a central and convenient location, from which power will be distributed by electricity to the various departments of the arsenal, comprising the small-arms cartridge factory, artillery cartridge factory, and carpenter shop, fuse, primer, and shrapnel factories, and general machine shop.

156. *Small-arms cartridges.*—The plant for the manufacture of small-arms cartridges has been increased during the year by the purchase or manufacture of a number of machines after many efforts in this direction. The plant is now complete for the manufacture, each eight-hour day, of 150,000 ball cartridges, caliber .30, and 42,000 others, such as revolver ball, caliber .38, blanks, etc.

157. *Piecework system.*—The system of payment for labor by the piece has during the year been successfully introduced into this department. This method of payment was adopted after a careful investigation of its advantages both to the Government and the employee. Considerable opposition was at first encountered from the employees, taking the shape of public meetings and written protests to the President, to the Secretary of War, and to this office. As was expected, this opposition has to a great extent disappeared, and the advantages anticipated to all concerned have been fully realized. The successful outcome of this important change is, to a great extent, due to the energy, ability, and interest displayed by Capt. O. M. Lissak, in charge of the small-arms cartridge department.

158. *Changes in manufacture.*—The quality of the metal used in the manufacture of cartridge cases is of great importance, and has given trouble in the past. The improvement of the brass is shown by the following statement. The metal is tested by firing 10 cartridges made from it repeatedly until all the cases are broken. The number of rounds fired divided by 10 gives the average endurance of the cases. The average endurance obtained from all the metal used was as follows:

	Rounds.
In the year 1898	7.0
First half, year 1899	7.6
Second half, year 1899	8.0
First half, year 1900	12.7
Second half, year 1900	19.3

and since January, 1901, 29 out of 34 lots of metal showed no breaks at 25 rounds, when the tests were discontinued. The improvements have shortened the process of manufacture.

159. The powder for the caliber .30 rifle has been furnished almost exclusively by the Laflin and Rand Powder Company, Pompton Lakes,

N. J. This powder has been of excellent quality, more than fulfilling the requirements of the specifications. These requirements will be more rigid than last year.

160. The department is making experiments to determine the best form of rifle bullet that will not only meet all the requirements for rifle practice at extreme ranges, but at the same time will preserve the waterproof qualities of the present .30-caliber bullet; the canellures for retaining the grease which seals the joint between the bullet and the cartridge case are supposed to interfere with steadiness of flight at long ranges.

161. *Quick-distributing packets.*—These packets, designed to facilitate the distribution of ammunition to troops on the firing line, were fully described in the last annual report. Of these packets, 2,000 were manufactured, filled with 200,000 cartridges, and issued July 29, 1901, to the commanding officer Manila Ordnance Depot. No reports as to the utility of these packets have up to this date been received.

162. *Reduced-range cartridges.*—It has been found that the conditions of target practice at many of the posts are such that the use of the service cartridges at from 500 to 1,000 yards has been attended with great danger to persons and property in the vicinity of the targets, due to misses and ricochets. Experiments have therefore been made at this arsenal with a view to the production of a cartridge which, fired at a range of 300 yards with 1,000 yards' sight elevation, would give an accuracy about equal to that of the regular cartridge at 1,000 yards. It was expected also to simulate the firing at 500, 600, and 800 yard ranges with the same cartridges, using the sight for the simulated range, and an actual range proportionally less than 300 yards, targets for these ranges being also reduced. Considerable experimenting was required to produce a cartridge that would fulfill these requirements; and as the demand for such a cartridge was urgent, it was decided that a cartridge charged with smokeless powder to give a velocity of about 900 feet per second and using the service bullet should be issued to the Army for trial at reduced ranges. Issues of these cartridges were made November 5 and 7 to the commanding officer Springfield Armory, and on November 22, 1901, to the following posts, viz: Plattsburg Barracks and Forts Sheridan, Snelling, and Thomas. Those sent to Plattsburg Barracks were subsequently forwarded to Fort Bliss, Tex., for trial. Suitable instructions were given with reference to the trial of these cartridges, and it was requested that the reports should consider and make recommendations as to—

1. The suitability of the cartridge for the purpose intended.
2. The form and dimensions of targets for the 300, 204, 125, and 89 yard ranges.
3. Any change found advisable in the velocity produced by the cartridge.
4. The practicability of the system as outlined above.
5. Any other system that may be considered preferable.

163. Very interesting and, on the whole, very favorable reports have been received from Springfield Armory and Fort Thomas, but decision as to the adoption of the cartridges is awaiting reports from the remainder of the posts above mentioned.

164. The two instances above cited illustrate the difficulty and delay attending changes in arms or equipments which depend upon reports of tests in actual service.

165. *Multiball cartridges.*—A suitable multiball cartridge for use of guards has been devised to avoid the danger from the extreme range of the service cartridge and is being issued to the service. The multiball cartridge for caliber .45 carbine, which is used for guards, contains three balls; for .30 caliber rifle it contains two balls. Issues of this multiball ammunition, caliber .30, to the National Guard have been made, and a reserve for both the National Guard and the regular service will hereafter be provided.

166. *Tests of ammunition for field and mountain guns.*—During the year the facilities for testing the components of the ammunition for field and mountain guns have been improved.

167. Considerable work has been done during the year in testing metallic cases, fuses, powders, and shrapnel (including pattern tests), and the presence of guns and facilities for making tests has been of great assistance in expediting the work of manufacture of these components of the ammunition.

168. *Shrapnel department.*—Pending the selection of a type field gun and carriage, nothing has been done in constructing field-gun shrapnel during the year except to make a few experimental lots from time to time for use in the guns undergoing trial.

169. About 7,500 steel shrapnel tubes on hand have been utilized to manufacture that number of shrapnel for the Vickers-Maxim mountain gun. These are base-charge shrapnel, weighing 12½ pounds and containing 334 steel-jacketed lead balls, weighing 170 grains each. The Frankford Arsenal combination fuse will be used with them.

170. An experimental model of a 6-inch base charge shrapnel is under construction, but has not been completed on account of the urgency of other work.

171. *Fuse department.*—As a result of experiment, study, and trial at this arsenal and by the Ordnance Board at the Sandy Hook Proving Ground, a new model of percussion fuse has been adopted to replace the present service model, which has not proved satisfactory for fuses of low resistance to arming. Even for high-resistance fuses the importance of the feature of absolute safety under all possible conditions is increased by the advent of high-explosive bursting charges for shell. When a shell is fired there are two forces acting on the fuse plunger which may be utilized to arm it—centrifugal force and pressure in the direction of its axis. The former is preferred, since very

high pressure in the direction of the axis may be produced by accidental dropping of a fused projectile, but under no conditions of handling incident to use in service could the projectile be rotated at a rate of 2,000 revolutions per minute. Many models of centrifugal fuses have been proposed, but none of them has been heretofore considered quite satisfactory.

172. The principles involved in this design, viz, (1) the use of a revolving firing pin that in its normal position is not directed toward the percussion primer, and (2) the restriction of functioning parts to the plunger itself, without connection to the fuse body, were suggested by Captain Dunn, the officer charged with the immediate supervision of fuse work and design.

173. All fuses heretofore designated as "M," "Low C," "A," or "W" fuses, on hand or recalled from service, are now being altered into centrifugal-acting fuses of the adopted type.

174. Detailed drawings and a pamphlet descriptive of fuses and primers are being prepared for issue to the service.

175. The average delay in the bursting of the shell is 0.02 second.

176. The fuse is intended for use in field projectiles—3-inch, 3.2-inch, and 3.6-inch breech-loading rifle, and 3-inch rapid-fire gun; also in the base fuse shell for 3-inch Hotchkiss and 2.95-inch Vickers-Maxim mountain guns.

177. *Detonating fuses.*—The first public test of the detonating fuse for armor-piercing projectiles, whose development has occupied a large part of the attention of this Department for several years, took place at the proving ground during the Gathmann-gun tests last fall. The results of that test were very satisfactory, and showed that we now possess a detonating fuse unequaled for safety and efficiency. About 20,000 of these fuses for siege and seacoast shell are now being manufactured, using fuse stocks on hand. In the meantime experiments are in progress to develop a cheaper and stronger stock for use with the fuse elements already developed.

178. *Time fuses.*—The service type of combination time and percussion fuse is now recognized as somewhat inferior to the best types of these fuses manufactured abroad. It is very difficult to make a good time fuse, and it is known that the improvements effected abroad represent an expenditure of much time and money. A novel form of time fuse, which promises to surpass the best foreign fuses in efficiency, is now being developed at this arsenal, and it is hoped that the manufacture of them in quantity can be undertaken during the coming fiscal year. In the meantime steps will be taken to provide the service with satisfactory fuses from wherever they can be obtained.

179. *Primer department.*—A combination electric and friction obturating primer for use in separate loading seacoast guns, an obturating friction primer for use in separate loading siege guns, and electric and

percussion primers for use in steel adaptors in 4.7-inch and 6-inch Armstrong guns have been developed and manufactured during the year. In addition small lots of special primers have been designed and manufactured for the 6-inch Bofors, the 3-inch Armstrong, and the 6-pounder Krupp guns. The plant for manufacture of nonobturating radial and axial vent primers has been in constant use during the year.

180. *Ammunition for the Armstrong 4.72 and 6 inch rapid-fire guns.*—All the ammunition for these guns was purchased abroad and has been turned in to this arsenal for examination and overhauling. The greater part was in a damaged condition; many of the igniters were torn and the igniting charges dissipated. Over 60 per cent of the cordite charges showed deterioration due either to actual exposure to sea water or to storage in damp magazines. All the pebble powder charges were condemned, as well as the electric primers originally furnished from England. Although this ammunition was originally packed in zinc-lined boxes, hermetically sealed, in every case the lining had been cut, apparently in many instances simply to verify the contents.

181. *Ammunition for 1-pounder subcaliber tubes.*—The components for 155,000 rounds are being procured by contract.

182. Tests of the projectiles for this ammunition showed that the explosion of the small bursting charge contained in the steel shell was not sufficient to increase the visibility of impact on water or target necessary for observation of the shot. The projectiles on hand, therefore, are to be used sand ballasted and with blank base plugs. The work of assembling this ammunition is in progress, and at the present time 10,000 rounds have been assembled.

183. To overcome the defect of the projectiles referred to above, a large-capacity steel shell, with point percussion fuse, was designed by the Ordnance Board, and 100 have been procured for trial. This shell is about 3⅝ calibers in length, and the bursting charge of somewhat over 1,000 grains of black powder, it is believed, will secure visibility of burst on impact.

184. *Chemical laboratory.*—The routine work connected with the examination of samples of nitrocellulose and of finished powders has been very materially increased by the greater number of samples received and by the greater amount of data required by more recent specifications.

185. The laboratory force has been increased by the employment of an additional assistant chemist, but it is still unequal to carrying on all the investigating work required. In this line some promising results have been obtained by Mr. A. P. Sy, principal assistant chemist, with a method of testing the stability of powders suggested by Captain Dunn.

186. The general idea is to subject the finished grain of powder,

sealed and unsealed, to continued heat, relying principally upon its actual loss of weight to determine the effect upon it. The following facts, some of them known before, have been established already by this investigation:

(1) All smokeless powders will gradually lose their volatile ingredients, the rate of loss being a function of (*a*) the kind of powder (composition); (*b*) its condition, good or bad; (*c*) the temperature; (*d*) the time of exposure; (*e*) the dimensions of the powder grain.

(2) There is, relatively, little difference in the residue of different kinds of smokeless powders after as much as 50 per cent of the total weight of the powder has been volatilized.

(3) The rate of loss, up to the percentage of nitroglycerin contained, is much more rapid for nitroglycerin than for nitrocellulose powders.

(4) After passing the earlier stages of decomposition (exact stage not yet known) a smokeless powder breaks down much more rapidly when sealed than when unsealed. It is thought that the time required to start decomposition is much shorter. If so, the practical result of this would be to require that all smokeless powder should be stored in open packages, and that the assembling of fixed ammunition should be delayed as long as practicable.

(5) A finished sample of smokeless powder breaks down much more quickly than the nitrocellulose from which it is made.

(6) The smaller the grain the more rapid the earlier stages of decomposition, but for extended exposures the rate of decomposition increases with the size of the grain.

(7) The indications are that 115° to 120° C. is about the temperature to use in order to differentiate between a good and a bad powder in a reasonably short time.

ROCK ISLAND ARSENAL.

187. A revocable license was recently granted by the Secretary of War to the city of Moline to construct and maintain a water main and settling basin at the northeastern part of the island, the basin to be in the water-power pool between what is known as Benhams Island and the main part of the arsenal and the water main crossing the head of the island and main pool to the city of Moline. This privilege is accorded upon the condition that the United States shall have the right to tap said water main with a pipe of its own, not exceeding 6 inches in diameter, and to take and use water therefrom without restrictions as to quantity and free of any cost or charge. The present water supply of the arsenal is taken directly from the Mississippi River without any intermediate settling, and during high water in the river is often almost unfit for use. As the license also prescribes that the work is to be done by the city, subject to the supervision and approval of the commanding officer, it has been stipulated that the Benhams

Island dam (now forming a part of the wall of the arsenal water power), which will bound the settling basins on the west, shall be repaired and strengthened by the city. Such work properly forms part of the construction of the settling basins, but will incidentally complete repairs to the pool boundaries which would in a few years probably have been necessary.

188. In December, 1901, a monument to mark the site of old Fort Armstrong, at the western point of the arsenal, was erected, with the cooperation of the commanding officer, by the Fort Armstrong Chapter, Daughters of the American Revolution, of Rock Island. Fort Armstrong, the first military post in this section of the Mississippi Valley, was established in 1816, and finally abandoned in 1836, having sheltered troops under the command of officers who later, as Presidents and general officers, attained distinction, and who contributed materially to the security of early settlers and assisted in the development and prosperity of the adjacent country.

189. For several years past the number of employees of the arsenal has been about 1,200, and with the authorized strength of the Army and the consequent demand for equipments, gun carriages, etc., it is probable the plant will be operated in future years upon at least the present scale. The small-arms machinery now practically installed and requiring only the special tools and fixtures adapted to the particular model of magazine rifle to be fabricated, will add, when in operation, about 800 workmen to the former number.

190. For the proper supervision of the varied operations of the arsenal as now conducted, the present number of assistant officers is insufficient and will be entirely inadequate when small arms, as well as gun carriages and equipments, constitute the output. At least three or four additional assistant officers will then be required, but as at present there are no quarters for such officers, the erection of not less than two sets for their accommodation should be begun without further delay, that they may be completed and ready for occupancy during the earlier stages of the operation of the plant, when the services of these officers will be most necessary.

191. Formerly the shops in the north, or Armory row, have been used for storage of field or siege gun carriages and limbers and of condemned and obsolete stores and those which have seen service in the field. Now, however, three of these shops have been taken for machinery for small-arms manufacture and part of a fourth will be used for the reception and storage of gun stocks and other material pertaining to such fabrications whenever they are commenced. As a consequence, the remaining space is very crowded and entirely inadequate for the proper and convenient storage of the output of the arsenal's gun-carriage department. Moreover, when manufacture and issue of a new type of field-gun carriage is begun, as will soon be the case, the 3.2-inch

gun carriages, etc., now in the hands of light batteries, will be turned in, and as, if repaired, they will form an excellent reserve supply that should be kept available to meet any sudden demand, they will undoubtedly be made fit for issue. At the present there is no suitable place where such equipment can be stored, and therefore the necessity for an artillery storehouse becomes still greater than formerly. Such a building was included in the plans of the arsenal.

192. The traffic compared with previous years shows a continued increase across the bridge and a continued decrease through the draw.

193. A revocable license has recently been granted to the Union Electric Telephone and Telegraph Company authorizing them to extend their wires across the island and across the bridges connecting it with the Illinois and Iowa shores, and it is understood advantage will soon be taken of this permission.

194. *Arsenal water power.*—Under the appropriation of $97,000 for strengthening the wing dam and enlarging and deepening the tailraces, work has been continued during the year, whenever the stage of water would permit, by the Moline Water Power Company, to whom a contract was awarded in July, 1900.

195. Under an additional appropriation in the sundry civil bill of March 3, 1901, of $130,500 for completing the tailrace channel through the slough south of the island, a contract was entered into on March 27, 1901, with the Moline Water Power Company. The company procured the necessary tools and appliances for executing the work, began operations late last autumn, and continued them this spring until an unusually high stage of the Mississippi compelled a suspension. So far about 143,000 cubic yards of gravel, sand, and silt have been dredged. It is anticipated the river will fall before the end of next month sufficiently to permit resumption of work.

196. *Development and transmission of power.*—The reconstruction of the power house, the increased development of the water power, and the substitution of electrical transmission for the old means by wire ropes have been described. The plant as thus established has been continued in operation throughout the past year with the utmost satisfaction and without expense for repairs. To the 72 motors installed in the shops during the previous year, 12 others have been added for elevators and further subdivision of the main lines of shafting, and as the manufacturing plant is further extended additional motors will be put in, the generators furnishing ample power for their operation.

197. The electrical heating of the power house during the winter of 1900–1901 was so satisfactory that the system was extended last winter to the office building, and that also proving an entire success, a similar system, comprising 140 electric heaters, has been established in the basement and first and second floors of Shop I, which has just

been occupied by the different departments of the harness shop. These heaters will require from about 125 to 200 K. W., depending upon the severity of the weather. The cost of their installation has been very much less than that of a suitable steam heating plant for this building, and as no additional employees will be needed in the power house, there will be no expense for operation, saving, as compared with steam heat, the cost of many tons of coal, of removal of ashes, and the wages of firemen.

198. *Cost of shops, power, and machinery.*—The arsenal comprises nearly 1,000 acres; its 10 main shops contain over 34 acres of floor space, and the available water power, if fully utilized, would provide over 5,000 horsepower. Established by act of Congress approved July 11, 1862, the development of the manufacturing plant and the storehouses, with the accompanying buildings, roads, sewers, etc., pertaining to a military post, has recently involved considerable expense, but, as the amount is frequently much exaggerated, it seems best now, at the conclusion of forty years of the arsenal's existence, to state the cost attending its establishment and its development to the extent previously mentioned in this report.

199. Gen. D. W. Flagler, in his History of Rock Island Arsenal, gave this summary up to 1877, the date of his history, grouping the items into periods corresponding to the administration of the officers who had regularly been assigned to command of the arsenal.

In the following table this summary is, in similar manner, continued to the date June 30, 1902:

Cost of buildings, water power, machinery, etc., at Rock Island Arsenal from its establishment to June 30, 1902.

Commanding officers.	Period.	Construction, repair, and preservation of buildings, roads, sewers, etc.	Construction, repair, and preservation of bridges.	Rock Island water power.	Machinery and shop fixtures.	Total.
Maj. C. P. Kingsbury	1863–64	$231,384.72	....	....	....	$231,384.72
Gen. T. J. Rodman	1864–71	1,855,455.62	$6,664.33	$440,506.35	....	2,302,626.30
Gen. D. W. Flagler	1871–86	4,137,675.24	160,894.74	591,911.47	$92,000.00	4,982,481.45
Col. T. G. Baylor	1886–89	201,200.00	96,250.00	322,000.00	44,000.00	663,450.00
Col. J. M. Whittemore	1889–92	69,000.00	182,318.48	101,000.00	25,000.00	377,318.48
Gen. A. R. Buffington	1892–97	47,250.00	315,125.50	67,500.00	47,500.00	477,375.50
Maj. S. E. Blunt	1897–02	141,351.40	32,612.12	207,856.00	722,461.90	1,104,281.42
Total		6,683,316.98	793,865.17	1,780,773.82	930,961.90	10,138,917.87

200. A large number of dummy cartridges for siege and seacoast artillery practice and metal frames and other material for the target practice of field artillery have been made during the year.

201. Thirty sets of pack outfits for Vickers-Maxim mountain gun have been completed and an equal number partly finished.

202. Three hundred and eighty-nine sets of artillery lead harness for two horses and 311 sets of wheel harness have also been made.

203. The manufacture of black leather horse equipments has been discontinued, and fair, or, more properly speaking, russet leather stuffed with oil is now used instead. The oil preserves the leather, makes it more pliable, and should remove the objections advanced against the use of the light-colored fair leather originally issued. Horse equipments, as well as cavalry and infantry equipments, have not been fabricated in complete sets, as some components require more frequent replacement and are therefore made in greater quantity than others, but the total fabrications would be equivalent to about 22,000 sets of horse equipments during the year; the issues have, however, been so extensive that less than 16,000 sets are now in store. More than this amount will be required to replace, as they are worn out, the black leather equipments now in service. It will therefore be necessary to continue manufacture during the coming year upon the same scale as at present, or even more rapidly if the necessary funds are available, in order that a proper reserve supply may be obtained.

204. About 16,000 sets of cavalry equipments and about 53,000 sets of infantry equipments (except blanket bags) have been fabricated during the year. Many large issues have been made to the Manila Ordnance Depot, to other arsenals, and direct to troops, but the supply now in store is about 12,000 sets of the former and 170,000 sets of the latter.

205. The few articles of equipment purchased from private makers have been diminished during the year by the manufacture at the arsenal of the spoons formerly obtained by contract; this has reduced their cost to the Government about 25 per cent and provided a better article. Knives and forks, the only remaining parts of the ordnance mess outfit still purchased, will also soon be made at the arsenal, the necessary arrangements being now in preparation.

206. The new plant installed in the past four years has so greatly increased the facilities of the arsenal for manufacture of saddles, bridles, saddlebags, carbine scabbards, halters, nosebags, spurs, surcingles, currycombs, haversacks, gun slings, canteens, meat cans, tin cups, and the many other articles of the soldier's ordnance equipment that, if run to its full capacity, about 200 sets of horse equipments and 2,500 sets of cavalry and infantry equipments can be made per day of eight hours, or about 500 sets of the former and 6,000 sets of the latter per twenty-hour day, the rate at which the arsenal was run during the Spanish war and at which it would undoubtedly be again operated as soon as employees could be secured, at least in the earlier days of another conflict.

207. This plant has also been so arranged as to afford space for additional machinery to permit considerable expansion, with consequent increase in output, without alteration of its existing disposition. It is therefore most probable that in any subsequent active military

operations, even if prolonged or of considerable magnitude, this arsenal would be able to provide all the ordnance equipments needed for the supply of a large army without being compelled, as in the Spanish war, to fall back upon private manufacturers, who, in the emergency, could only furnish inferior articles at an increased cost.

208. Besides the standard equipment a number of articles were made during the year and issued to the service for trial. The principal of these were the Magnolia or noncorrosive metal bits, curb chains as a substitute for the strap, curb bits with lengthened upper branch, saber scabbard shields, double spring snaps for watering bridles, nosebags with duck bottoms, leggings with attached spurs, several kinds of linchpins for field-gun carriages, and a new form of artillery neck yoke.

209. The principal changes in model that have been approved are the new and heavier nickel-plated watering bit and the nickel plating of curb bits and saber scabbards.

210. Boards of officers have tested and reported at different times upon a variety of articles sent to this arsenal for examination. The principal of these are roller bearings for artillery carriages, which were the subject of extended consideration; pack outfits for Colt automatic gun, woven cartridge belts, different forms of canteen, a metal cartridge box, etc.

211. *Small-arms plant.*—The preparation of Shops B, D, and F for occupancy of workmen and reception of machinery for the manufacture of small arms, which was reported upon in detail last year, has been completed, and such of the machines as have been delivered have been installed.

212. There have been ordered from private manufacturers during a former fiscal year and in that just closing a total of 933 machines, and 141 others are being made at this arsenal. Of the former number 864 have been delivered, including all but a portion of the profilers and drop hammers, and both of these, upon which deliveries are rapidly being made, will probably be fully installed within three months.

213. Of the machines being made at this arsenal 128 have been completed, and good progress made upon the others, which will be finished by the time the machines due on contracts are received.

214. There remain to be purchased or made 49 other machines, such as automatic screw machines, automatic bench drills, etc., which have not yet been ordered, as certain of their features must be determined by the particular model of gun to be manufactured, and as yet only such machines as would be entirely available for any model have, under existing orders, been procured.

215. In addition to the machines themselves, a large number of fixtures for holding during manufacture the parts of the arm and of milling and other tools for making the different cuts will be required

before actual fabrication of rifles can be commenced. It is proposed to make these fixtures and tools at this arsenal, and they could have been completed and now ready for use if their preparation had not been delayed, in accordance with existing instructions, until it was decided whether the present model of magazine rifle should be made or one of a new design which is now being manufactured at the Springfield Armory for trial in service.

216. Eight hundred and fifty-nine thousand dollars have been appropriated for the establishment of this armory, of which $619,685 have been expended.

217. *Receipts and issues.*—Receipts and issues of ordnance stores during the past fiscal year were as follows:

	Pounds.
Receipts	2,988,877
Issues	5,959,375
Total	8,948,252

to which must be added many hundred thousand pounds of machinery, mostly for the small-arms plant and for the water and electric power and for the material used in the year's manufactures.

218. The gross amount is about 60 per cent greater than last year and more than for any previous year, except the unusual one of the Spanish war. With the new sidings put in the previous year it has been quickly handled and the operations of loading and unloading cars conducted with facility and economy.

AUGUSTA ARSENAL.

219. This arsenal is the headquarters of the Southern armament district, in which capacity it is charged with making repairs, alterations, and improvements to the armament of the fortifications of the Gulf coast and other Atlantic coast south of Fort Monroe and with the manufacture of artillery targets and certain minor parts of guns and carriages for repair or replacement in that district, and is used as a depot for the storage and issue of ordnance and ordnance stores to troops in the Department of the East south of Fort Monroe.

220. This arsenal being only to a small extent a manufacturing arsenal, it has been possible to concentrate its efforts upon the maintenance and improvement of installed armament in its district, to the success of which efforts the satisfactory condition of that armament bears witness.

221. The arsenal is especially well located for the purposes for which it is now utilized; but in order that it may be operated with more economy the receipt and shipment of supplies should be facilitated by the construction of a side track connecting with the electric railway, and electric power should be installed to a moderate degree where

advantageous. The health and comfort of garrison would be materially benefited by the installation of a modern system of sewerage, an increased water supply, and new barracks for the enlisted men.

SANDY HOOK PROVING GROUND.

222. Experimental and proof firings have been conducted in the usual manner. The additional facilities of the new proof battery have rendered possible the rapidly increasing amount of experimental and other work. Of these the exhaustive competitive test of new material and of the Gathmann 18-inch gun and projectile are the most important, the former by the Ordnance Board and the latter under a joint board of army and navy officers. It is to be noted with satisfaction that no casualty has occurred, in spite of the precarious nature of the work involved.

223. *Test of projectiles.*—A large force has been constantly employed in handling heavy armor and in preparing both timber backing and sand butts. Ballistic test of service steel projectiles received from contractors have been made as follows:

15-pounder shrapnel,
6-inch A. P. shell,
8-inch A. P. shell,
10-inch A. P. shell,
10-inch A. P. shot,
12-inch A. P. shell,
12-inch D. P. shell,

representing 47 different lots.

224. Proof work has continued to increase. For the year ended June 30, 1901, there were fired 5,568 rounds; for the year ended June 30, 1902, 10,755 rounds. An increase in the number of firing records and in the general correspondence has naturally followed.

225. *Guns proved.*—The following guns have been proved:

5-inch R. F. guns	11
5-inch B. L. siege guns	18
6-inch B. L. rifles	27
7-inch B. L. howitzers	6
7-inch B. L. mortars	27
12-inch B. L. rifles	4
12-inch B. L. mortars	42
Total	135

226. A large amount of powder for guns of all calibers has been tested, involving a great deal of careful firing.

227. *Machine shop.*—The shops have been pushed to their utmost throughout the year. The floor space has been increased by building a wing parallel to the present shop and connected thereto by a passage-

way, which also admits the passage of cars bringing in material. This addition should have been completed May 1, but the failure of the lumber contractor to deliver suitable flooring has prevented completion up to the present time.

228. The repair work of the artillery district continues to occupy much of the machine-shop force.

229. In addition to this work there has been devised and manufactured:

Safety-firing attachments for 4.72 and 6 inch rapid-fire Armstrong guns;

Electric-firing attachments for service guns, both seacoast and rapid-fire;

Safety-lanyard attachment for seacoast guns on disappearing carriages;

And 8-inch and 10-inch Parrott projectiles have been rebanded for target practice.

230. *Smith shop.*—Floor space has been added to the smith shop for a small brass furnace, and for preparing the necessary molds for making castings up to 250 pounds in weight. With this addition great delay in procuring small castings will be avoided.

231. *Structural work.*—During the year the following construction work was completed at the proof battery:

One concrete emplacement for testing experimental carriages;

One set of gun skids for parking rapid-fire guns of 5-inch and 6-inch caliber.

Equipment of Gantry crane for operation by electricity.

232. This involved installing on the crane and its car six 7½-horsepower motors and one 1½-horsepower motor, together with the necessary controllers, switches, etc.

Installing a special trolley system that would not interfere with the various movements of the crane nor obstruct the work of the battery.

Installing two 35-horsepower direct-connected high-speed engines and two polyphase 25 K. W. direct-current generators.

Installing one 50-horsepower horizontal boiler.

Complete switchboard with necessary ammeters and voltmeters for the two generators.

233. This equipment will be of the greatest value in expediting proof work. In its test a 12-inch rifle weighing 52 tons was removed from the proof carriage and placed on a car in twenty-seven minutes. Formerly this operation would have required at least four hours.

234. The sewer system referred to in the last report of the commanding officer has been completed. All occupied buildings belonging to the proving ground are now properly sewered and are in excellent sanitary condition.

235. *Railroad.*—About 3,000 feet of new track have been laid in

strengthening the old track, in changing track to avoid new emplacements being added to Battery Halleck, and in providing a proper approach to the dock. About 8,000 new ties have been put in and culverts renewed and repaired.

236. The passenger train service inaugurated in May, 1901, has proved satisfactory. Three coaches belonging to the Ordnance Department and one belonging to the Engineer Department make up the train. In addition to the employees of these departments, the enlisted men and civil employees of Fort Hancock (from 20 to 40 daily) are carried. Passes issued by the commanding officer of that post are accepted on both the railroad train and on the steamer *Ordnance.*

237. Counting each trip of a passenger on the train, between 50,000 and 60,000 passengers have been carried during the year.

238. *Freight received and shipped.*—The following statement shows the weight of freight received and shipped during the fiscal year by the railroad, of which the length is 6 miles, from July 1, 1901, to June 30, 1902, viz:

Received .... pounds..	12, 738, 420
Shipped .... do....	5, 668, 786
Total .... do....	18, 407, 206
Number of loaded cars received	415
Number of loaded cars shipped	169
Total	584

239. Issues to fortifications:

Guns and mortars:	
6-pounder rapid-fire guns	15
5-inch rapid-fire guns	11
5-inch breech-loading siege rifles	6
6-inch rapid-fire guns	24
10-inch breech-loading rifles, steel	1
12-inch breech-loading rifles, steel	3
12-inch breech-loading mortars, steel	32
Total	92
Carriages:	
Parapet carriages for 6-pounder rapid-fire guns	15
5-inch barbette carriages, model 1896	1
10-inch disappearing carriages, L. F., model 1896	1
Total	17

Many of the gun carriages are issued from the places of manufacture directly to the fortifications, and are proved in place.

ORDNANCE BOARD.

240. The following list gives the subjects considered and reported upon by the Ordnance Board during the fiscal year ended June 30,

1902, with the dates on which reports were submitted and the conclusions of the board with reference to the subject under examination, viz:

Subject.	Date of report.	Nature of report.
3-inch American Ordnance Co. mountain-gun outfit.	July 5, 1901	System defective and material returned to company.
3-inch Bethlehem Steel Co. mountain-gun outfit.	Oct. 26, 1901	Tested; defects developed. Material returned to company for alteration.
3-inch B. L. field gun No. 1, model 1898, separate loading.	May 22, 1902	Test completed.
3-inch B. L. field guns and carriages for selection of service type.		Two guns and carriages quite satisfactory, but with defects stated.
3-inch R. F. 15-pounder gun and mount, Bethlehem Steel Co.	Endt. Apr. 15, 1902.	Design qualifiedly approved, subject to test.
5-inch R. F. gun firing device	July 2, 1902	Hand ejection recommended. Magneto firing box to be tested.
6-inch Vickers-Maxim R. F. gun and mount	Feb. 26, 1902	Preliminary firings and programme of tests.
6-inch Bofors R. F. gun	Apr. 4, 1902	Do.
6-inch R. F. Armstrong gun, modification of firing mechanism.	June 26, 1902	Changes tested and recommended.
12-inch B. L. mortar firing device and lanyard pull.	Dec. 31, 1901	Patterns tested and recommended.
18-inch Gathmann torpedo gun	Endt. Oct. 2, 1901	Recommendations for distance of targets, etc.
Carriages.		
5-inch siege carriage, loop piston rod attachment.	Dec. 28, 1901	Tested; not satisfactory.
Breech strap for 5-inch siege gun	Mar. 24, 1902	Progress report.
7-inch B. L. mortar carriage and platform, model 1895.	Oct. 2, 1901	Changes tested; satisfactory.
7-inch siege howitzer carriage, model 1899	Mar. 8, 1902	Preliminary firings; throttling bars unsatisfactory.
10-inch pneumatic disappearing gun carriage	Endt. Oct. 22, 1901.	Completion of test noted.
12-inch disappearing carriage, model 1896, No. 25.	Jan. 8, 1902	Test satisfactory.
12-inch mortar carriage, model 1896, altered for 70° elevation.	June 26, 1902	Test not satisfactory.
Ammunition and target practice.		
3.2-inch smokeless powder charges and shell charged with thorite mixture; returned from Philippines.	Feb. 28, 1902	Test not satisfactory.
Drill cartridges for 6 and 15 pounder guns	Apr. 3, 1902	Test completed; recommended.
Reduced charges of smokeless powder for target practice.	Mar. 29, 1902	Charges determined for 8-inch, 10-inch, and 12-inch guns, 1,050 feet per second velocity.
Saluting charges (black saluting powder) for 8, 10, and 12 inch guns and 12-inch mortars.	July 3, 1902	Charges determined for pieces named.
Projectiles.		
Illuminating shell	July 22, 1901	Tested; utility doubtful.
Experimental 3-inch shrapnel	Aug. 27, 1901	Tested and recommended.
Least caliber for subcaliber practice with 12-inch B. L. mortars.	Apr. 30, 1902	No smaller caliber than 3.6-inch mortar shell with bursting charge can be used.
3.2-inch steel shell, large capacity for high explosives.	Aug. 31, 1901	Ballistic test satisfactory.
5 and 7 inch steel shell, large capacity for high explosives.	Sept. 4 and 18, 1901.	Do.
NOTE.—These shells comprise lots of 100 3.2 inch and 50 each 5 and 7 inch, procured by the commanding officer, Frankford Arsenal.		
Isham 12-inch shell for high explosives	May 23, 1902	Test inconclusive.
Fuses and primers.		
Broderick base percussion fuse for subcaliber projectiles.	Oct. 8, 1901	Tested; failed on water impact.
Stevens's time fuse, base insertion	Nov. 13, 1901	Test not satisfactory.
Frankford Arsenal base percussion fuse for field, siege, and seacoast service.	Jan. 9, 1902	Summary of tests; type recommended.
Detonating fuse for field, siege, and seacoast service.	Dec. 23, 1901; May 27, 1902.	Types recommended. Progress report experimental fuses.

Subject.	Date of report.	Nature of report.
Fuses and primers—Continued.		
Test of Frankford Arsenal 15-second combination fuse for burning in flight.	Sept. 25, 1901; Oct. 23, 1901; Dec. 3, 1901.	Progress of tests.
Frankford Arsenal experimental 20-second combination fuse (Dunn).	Feb. 19, 1902; May 28, 1902.	Do.
Axial vent friction primers for subcaliber tubes.	Nov. 8, 1901	Tested and recommended.
High explosives.		
Tests of Explosive D and maximite	Dec. 17, 1901	Supplementary report of 3 rounds against heavy armor.
Methods of investigation and test	Mar. 7, 1902	Information for publication.
High explosive—John Kraetsch	Sept. 30, 1901	Tested in laboratory; not recommended.
Sights.		
Night sights for seacoast guns. Warner and Swasey.	July 3, 1901	Tested; utility doubted.
Bar sight, 5-inch R. F. gun. Warner and Swasey.	July 17, 1901	Tested; modifications recommended.
Telescopic sight with vertical and horizontal scales.	June 21, 1902	Tested and recommended in part.
Implements and instruments.		
Extractors for 1-pounder shell in subcaliber tube.	Jan. 8, 1902; Mar. 31, 1902.	Sample tested; satisfactory.
Shot tongs, New Jersey Foundry and Machine Co.	July 19, 1901	Test unsatisfactory.
Zeiss stereoscopic binocular range finder	Feb. 11, 1902	Tested and recommended for trial in field.
Miscellaneous.		
Towing target	Oct. 10, 1901	Pattern constructed; tested and recommended.
Lubricating oil for gun carriages and breech mechanisms.	July 2, 1902	Oils tested and specifications submitted.

POWDERS.

241. At the close of the fiscal year ended June 30, 1901, the amount of smokeless powder under contract and unfinished for the various calibers of mountain, field, rapid-fire, siege, and seacoast guns and mortars was 882,275 pounds. The amounts ordered for the same guns during the fiscal year ended June 30, 1902, were 736,368 pounds. The amounts delivered during the fiscal year ended June 30, 1902, were 996,855 pounds, leaving 621,788 pounds still due.

242. Though the amounts due are still "undelivered," it may be stated that, with the exception of one powder plant, all the powder companies have finished their orders and have the powders in the drying houses, thus insuring their early tests and acceptance during the present fiscal year. Delays in an early completion of the work have been largely unavoidable, and have been due to necessary changes in plant and treatment of nitrocellulose and of powders to comply with the present requirements of the Ordnance Department. The companies that have finished their orders are now able to begin work as soon as any allotments under new appropriations can be made and to continue such work up to the capacity of their plants. It should be said to the credit of the powder companies that they have all willingly

gone to the expense—in some cases quite heavy—of making alterations and additions to existing facilities in order to improve the quality of their output. They have one and all and at all times shown commendable willingness and liberality in expenditure in order to comply with the wishes of the Department regarding what was believed to be the best methods for the production of a powder that, so far as known, would be the equal of any product elsewhere. While no claim is made that further changes may not be required, as experience will probably show, it can be stated that at the present time excellent results in the production of a smokeless powder have been accomplished.

243. *Changes in specifications for the manufacture of smokeless powders.*—After eighteen months' experience in the manufacture of nitrocellulose powders it became evident that alterations and improvements in methods of manufacture, especially of the nitrocellulose, could be made. These were embodied in specifications under date of August 15, 1901, which specifications were again revised and published May 1, 1902. The methods adopted have brought about important changes in the purification of the nitrocellulose.

244. *Heat tests.*—The subject of proper tests for the stability or keeping qualities of nitrocellulose and of smokeless powders is most important. It is one that has led to much investigation and discussion both in this country and abroad. The problem is still far from a satisfactory solution. When nitrocellulose is exposed to heat there is a breaking down of its molecular structure and an evolution of nitro-oxygen compounds. The rapidity of this decomposition depends on the temperature, the rate being greater the higher the temperature. All present heat tests are based on these facts. They assume that if a given lot of nitrocellulose will stand exposure to a certain temperature for a determined period of time it will stand exposure to the ordinary atmospheric temperatures for an indefinite time. This relation between time, temperature, and decomposition may be assumed, although it has not been satisfactorily proven.

245. It may be said that no test has yet been devised that will differentiate the keeping qualities of different samples of nitrocellulose. The final test must still be prolonged storage under ordinary temperatures and conditions. On this point Professor Will, of the Central Laboratory, near Berlin (an authority upon the subject), remarks as follows:

> Existing experience extending over many years justifies the assumption that there can be no doubt as to the possibility of producing nitrocellulose of such stability that, if stored under proper conditions, it can be kept indefinitely without fear of decomposition.

246. *Powders of pure nitrocellulose and of nitrocellulose combined with nitroglycerin.*—The much-discussed question heretofore of the use of a proportion of nitroglycerin in smokeless powders is gradually

solving itself as time and experience show what can and what can not be done with each. When nitroglycerin is used the same ballistic results will be obtained with a smaller charge than with nitrocellulose powders. If properly made there is no reason why such powders should not also be perfectly stable. It should be stated, however, that the dangers of the manufacture of such powders are much greater than in the case of those containing nitrocellulose only. With the latter powders dehydration by means of alcohol has reduced such dangers to a minimum.

247. Within a few years, as smokeless powders developed, the chambers of guns have been enlarged, larger charges of powder have been used, and great increases in velocities have been obtained without increasing the limiting pressures. It has been found abroad that when such velocities were obtained with nitroglycerin powders, of which cordite and ballistite are probably the best-known types, the erosion in the bore near the seat of the projectile and at the beginning of the rifled part of the bore was very great. This erosion was due to the high temperature of the gases, combined with their rush, and caused a rapid enlargement of the gun at the parts named above. This action of the gas was most marked on the lands, which wore away after a time so completely that the projectile would not be properly rotated. It then became necessary to reline the gun, at much expense and loss of time. It is stated that "a heavy gun, after not much more than 100 rounds with full charges, may be enlarged as much as half an inch, and would lose 150 feet per second or more in muzzle velocity." This enlargement refers, as stated above, only to the seat of the projectile and the lands adjoining, not to the bore throughout.

248. A consideration of these facts has caused a widespread desire for powders that would give the high velocities now universally demanded and yet would not give excessive erosions.

249. *Granulations.*—Heretofore the Ordnance Department has used for nearly all guns a cylindrical grain having seven longitudinal perforations. The length of the finished grain is about twice its diameter. With such a grain most excellent ballistic results have been obtained. Furthermore, it is probably the easiest and most economical form of grain to manufacture. The principal objections to this form of grain, however, are as follows: A cartridge bag must be used in loading it. This is always a source of trouble, and gives rise to smoke in firing. When the cartridge bag is long, as, for instance, the bag of the 6-inch R. F. gun, it is impossible to make it rigid. It consequently bends and slides around while being handled, and when inserted in the gun chamber is liable to buckle somewhat, thus necessitating greater exertion and probably a loss of time. The charge should be equally distributed throughout the longitudinal cross-section of the chamber to obtain the best results. For the same gun the

charge varies with different lots; therefore for the best effects it would be necessary to have a cartridge bag with an adjustable cross section. The character of the grain makes it more difficult to secure uniform ignition with it than in the case of a strip or tube form.

250. During the year a form of grain devised at the works of E. I. Du Pont de Nemours & Co. has been tested at Sandy Hook. It is a rectangular cross-section, multiperforated grain, and equal in length to the chamber or section of the cartridge. Transverse perforations extend into the longitudinal perforations at distances depending upon the gun in which the powder is to be used.

251. These grains can be easily manufactured for any gun, though they would be more expensive than the present form.

252. The test of a sample of this granulation in the 6-inch gun gave very uniform results. It is therefore a question whether the advantages gained by such form of grain—namely, stiffness of the cartridge, equal distribution in the gun chamber, and facility of ignition—would warrant an increased expenditure.

253. *Ignition charges.*—Nitrocellulose powders being difficult to ignite, igniting charges of fine-grain black musket powder, in amounts from 1½ to 2½ per cent of the entire weight of charge, have been used in firing. The present igniting charges, as established for guns of various calibers, have proven very satisfactory in giving uniform ballistic results. Experiments have, however, been made looking to a reduction in the amount of black powder to be used.

254. *Reworking of brown, black, and smokeless powders.*—For some years there had been on hand at the powder depot a large amount of old black powders of irregular and obsolete granulations. These have been sent to the Du Pont works and have been returned regranulated for saluting powders. About 126,000 pounds of serviceable saluting powders have thus been obtained.

255. Twenty-eight thousand and six hundred pounds of brown powders have been redried, and 20,340 pounds of similar powders for different calibers have been reworked. These powders will be used for testing guns and carriages.

256. About 100,000 pounds of old nitroglycerin powders are now being reworked into strip powders for the 12-inch B. L. rifled mortars. Such lots of finished powders of this class as have so far been tested have given excellent ballistic results. The work upon this powder will probably be finished before January 1, 1903.

257. *Powder storage.*—Nearly all of the smokeless powders so far manufactured have been kept in store at the powder depot at Dover, N. J., and at the Benicia Arsenal, Cal. The Department has begun to avail itself of the excellent storage facilities at the St. Louis Powder Depot. Already about 130,000 pounds have been received there. It is contemplated to keep an extensive reserve supply of such powders on hand there for issue to the South Atlantic and Gulf posts.

258. *High explosives.*—During the year contracts have been awarded for quite a large amount of explosive materials as shell fillers. In view of the confidential nature of all details pertaining to this subject, nothing but a general statement regarding the matter will be here given. The firm to whom contracts have been awarded has constructed a temporary plant that will give, at present, about 1,000 pounds of finished material per day. The firm is also engaged in erecting a permanent plant, which will, when completed, be of sufficient capacity to furnish the Ordnance Department in full with any amount of high-explosive shell filling that may be required.

MANILA ORDNANCE DEPOT.

259. The examining of ordnance property returns of officers in the Philippines still forms a most important part of the duties of the chief ordnance officer, and time has proved its value. It is of great assistance to the Ordnance Office in Washington in relieving it of the preliminary examination of returns, and it is of much benefit to officers in the Philippines, as it greatly facilitates the settlement of their accounts, the correction of errors, and adjustment of misunderstandings.

260. *Transfer of ordnance stores to the civil government.*—Under proper authority a large number of arms and ordnance stores have been transferred to the civil government, the value being $24,737.86.

261. In addition to this, Springfield carbines and ammunition, with cartridge belts and their accompaniments, to the value of $49,968.65 have been sold to the civil government. Also a large amount of stores has been transferred to the Philippine constabulary, consisting of Remington rifles and cartridges. The total value of all stores transferred to the constabulary, excepting Remington rifles and ammunition, amounts to $121,406.39.

262. Horse equipments which have been acted on by an inspector have been sold to teachers to the value of $1,808.75, this sale having been authorized by the Secretary of War.

263. *Issue and receipt of stores.*—The number of requisitions received from troops in this division amounted during the year to 1,980, and from the Philippine constabulary to 50, making a total of 2,030.

264. The total number of issues made from July 1, 1901, to June 30, 1902, amounted to 2,454.

265. In making issues on requisitions the policy was followed of keeping each organization fully equipped, and no more, with serviceable stores. Certain kind of stores, like nosebags, halter straps, meat cans, etc., were issued slightly in excess of the strength of the organizations on account of the continued and hard service that such articles were subjected to.

266. A liberal allowance was issued of harness oils, soaps, emery

cloth, etc. In the issue of black leather oils, soap, emery cloth, etc., the allowances prescribed for troops in the United States were more than quadrupled.

267. In addition to the supply of troops the following gunboats have had their armament supplied at this depot: *Charleston*, *Florida*, *Napidan*, *Lexington*, *Portland*, and *Erica*, and launch *Buffalo*.

268. During the year 49 companies of native scouts, out of the 50 organized in this division, were equipped with Springfield carbines, caliber .45; Colt revolvers, caliber .45; cartridge belts, caliber .45; carbine-ball ammunition, caliber .45, and the various articles constituting the equipment of the infantry soldier. To one company—the Forty-fifth—stationed at Paranus, Samar, Springfield carbines, caliber .45, have not yet been issued to replace the Springfield rifles now constituting the arms of that company.

269. A large number of experimental stores have been issued for trial and report in this division, among them being Luger automatic pistols, woven canteen and gun slings, canteen-haversack slings, Hoff's first-aid packets (woven), spokane bits, cleaning cords for rifle and carbine, ball cartridges in special waist belts having 100 cartridges in each belt and packed in end-opening quick-delivery boxes, ball cartridges in strong paper boxes which were fastened in either a bandolier or packet style, and all packed in end-opening quick-delivery boxes.

270. The unserviceable ordnance stores received from troops in the division and placed before an inspector for condemnation numbered 505,158 items, the cost of which was $200,631.34.

271. The large number of certain unserviceable articles is due not only to receiving unserviceable property from troops, but to the large quantity which was found on hand when the storehouses were overhauled.

272. The ordnance and firearms received from the insurgents during the year by purchase, capture, and surrender are as follows:

CAPTURED AND SURRENDERED.	
Cannon, various	50
Mauser rifles	648
Remington rifles	2,181
Springfield rifles, caliber .45	31
United States magazine rifles and carbines, caliber .30	165
Amberg rifles	64
Miscellaneous rifles	1,076
Miscellaneous revolvers	566
Miscellaneous shotguns	811
PURCHASED.	
Mauser rifles	583
Remington rifles	1,316
Springfield rifles, caliber .45	7
United States magazine rifles and carbines, caliber .30	156
Amberg rifles	78

Miscellaneous rifles	1,109
Miscellaneous revolvers	271
Miscellaneous shotguns	124

273. The amount of money disbursed during the year from ordnance appropriations was $63,116.57. About $8,500 will be required for the payment of the June pay roll of employees and other liabilities incurred in June and chargeable to the appropriations for the fiscal year 1902.

274. *Supply of ordnance stores to other departments.*—During the year ordnance stores have been sold to the U. S. Marine Corps to the value of $1,010.32, payment for which has been made to this depot. A number of stores were also transferred to the Marine Corps and accounts for the same sent to Washington for settlement.

275. Certain ordnance stores were, by authority of the Chief of Ordnance, on January 24, 1902, issued to the Coast and Geodetic Survey for use on the steamers *Research* and *Pathfinder*. Receipts for these stores were forwarded to the Chief of Ordnance for settlement February 24, 1902. Sales of small quantities of ordnance stores have also been made for the use of the Quartermaster's Department.

276. *Carpenter shop.*—The carpenter shop has now a foreman and assistant foreman, the latter but recently arrived, both Americans, and 37 native and 12 Chinese carpenters. This number will shortly be reduced to about 30, as an increase was made in April to accomplish a large quantity of work on hand for the last quarter.

277. *Machine shop.*—The machine shop, blacksmith shop, and power plant have been during the year under the charge of one American foreman, but during the month of June an assistant arrived, so that the superintendence is now sufficient. Eighteen natives are employed.

278. All the installation of new machinery and all the plumbing work have been done by these shops, as well as all repairs of tools and machinery. These items are considerable, as much of the old plumbing needed to be changed and much new put in. The tools and machinery, being largely of old design and worn, needed constant attention. In addition to the above, numerous stores have been fabricated and repaired in the shops, and various guns cleaned and oiled, mounted on gunboats, and shields assembled to the Gatling and Hotchkiss carriages.

279. It was reported by the officers in charge of the Vickers-Maxim mountain batteries that the pack saddle furnished for carrying the trail was unsatisfactory, as the pack was very heavy and the trail very long. A new frame for the trail was devised at the depot, with the assistance of the officers mentioned above. The new frame is to be used on the quartermaster aparejo, and is secured by the aparejo cincha. The frame has not as yet been thoroughly tested, but officers who have tried it are of the opinion that it is a great improvement over the old one.

280. *Harness shop.*—The harness shop is superintended by an American foreman and assistant, and it employs 27 natives. The principal work done was the fabrication of a large quantity of leather stores and cleaning and repairing, blackening, and oiling stores of the same kind.

281. *Armory.*—The armory is under an American foreman and it employs 60 natives. Men on the pay rolls of this shop have done the electrical and the masonry work, the latter in building drains and sheds, making alterations, erecting furnaces, concreting, etc. They are also valuable in the armory when not otherwise employed. The principal work in this shop has been the cleaning, repairing, rebluing, and oiling of the various small arms, sabers, bayonets, etc., turned into the depot.

282. *Tin shop.*—The tin shop and retinning plant are under the superintendence of an American foreman, who is also in charge of the painters. The helpers work at retinning when the plant is in operation and assist the painters at other times. There are four native painters, four native tinners, and four native helpers.

283. *Foundry.*—The foundry employs one American foreman and two natives. A large amount of casting has been done in this shop, and a quantity of condemned ammunition exploded in the relined cupola furnace. The advantage of the foundry will be recognized when it is stated that before its reemployment by the American Ordnance Department prices for ordinary castings as high as 20 cents a pound had been asked by private establishments.

284. *Machinery.*—Certain new machinery, consisting of a twist drill grinder, a planer, bolt cutter, paint mill, pressure blower, an emery grinder, and a Worthington steam pump, have been received and installed, and are adding to the quality and decreasing the cost of the work done. A supply of tools has been received for the tin shop, so that any kind of work can be advantageously done.

285. The new pump, in connection with 2,000 feet of fire hose and three hose carts, constitutes a very effective equipment in case of fire.

286. The depot is now supplied with a complete and excellent system of sewerage.

287. *Additions and improvements needed.*—Attention is invited to recommendations before submitted and indorsed by the inspector-general of the division in his report of last year for improvements needed in buildings and shops; the most important of them being the introduction of electric power, requiring a new engine with dynamo to supply power for motors running machines and to furnish electric light. The lighting is now most unsatisfactorily done from city supply. The introduction of electric power would be of especial advantage in case of fire at night, as the force pump could be put in

operation instantly. To maintain this now would require keeping up steam in the large boiler over night and having an attendant constantly on hand.

288. The depot is still overcrowded for shop room and it is most desirable to push to completion the Spanish building intended for offices and left partly finished at the time of American occupation. Nothing has been done toward finishing this. When it is completed the present office rooms can be utilized for extension of shop room.

289. Under an order of the military governor a reservation of ground around Fort San Antonio Abad was set apart for an ordnance proving ground. This was never used and it was not well suited by position for this purpose. There is no doubt that there should be a place readily accessible from the depot where small arms could be tested for accuracy and firing could be done with field or siege guns. Within the depot itself small-arm velocities can be determined, but no more.

290. Many improvements are needed at the depot, but it seems undetermined whether the action for their accomplishment should center in the Philippine Government or in that at Washington, or from the revenues of which the funds should come. It may perhaps be tentatively stated as a general principle that military expenditures for the purpose of preserving the peace and good order of the islands, once established, should be taken care of from their own resources, and that those which result from the maintenance of the Philippines considered as an outpost guarding the interests of the United States in the Far East, should be borne by the central government. If such a rule were established the administration of the depot would know where to look for attention to its different classes of needs.

291. *Offices.*—In the correspondence office the system of filing has been considerably developed and improved during the past year. The card-index system and the flat subject file, which gives the entire correspondence pertinent to a given subject in one bound volume, are the principal features.

292. The total number of civilian clerks employed is 16, one of whom is a native. Nine enlisted men are also employed in the office.

293. There has been on duty at the depot an ordnance detachment consisting of 4 sergeants, 6 corporals, 12 first-class privates, and 13 second-class privates. Five ordnance sergeants have also been on duty at the depot. Seven ordnance sergeants are distributed throughout the division at various posts.

MIDVALE STEEL WORKS.

294. All the orders and contracts unfinished June 30, 1901, have now been completed. Of the orders and contracts received during the

current fiscal year 12 remain unfinished, of which the following are the most important:

700 12-inch torpedo shell, 1,000 pounds, model 1895.
800 6-inch A. P. shell, model 1898.
7 12-inch disappearing carriages, L. F., model 1901.
1 forging and 6 castings for the Buffington depressing carriage for 16-inch B. L. rifle, model 1901.

295. *Projectiles.*—A contract for projectiles for 12-inch A. P. shell, 12-inch D. P. shell, 12-inch torpedo shell, 10-inch A. P. shell, and 6-inch A. P. shot, dated July 22, 1901, is being promptly executed. Ten-inch and 12-inch A. P. shell and 12-inch D. P. shell were completed from thirty to sixty days in advance of the contract time, and 12-inch shell and 6-inch A. P. shell remaining to be finished are well under way, and will in all probability be completed from two to three months of their contract time of delivery. All the projectiles furnished under this contract are of a high standard, except two of the four lots of 12-inch D. P. shell, which were only accepted after a retest.

296. *Twelve-inch carriage, L. F., model 1901.*—On November 14, 1901, a contract was placed with The Midvale Steel Company for seven of these carriages. This model carriage differs from the model 1897 carriage, which it supersedes, in the following details:

297. A sighting platform extends along each side of the carriage. Ladders are provided at the front and rear ends of both platforms. The sight parallel bar is fitted to receive a standard combination bar sight, including an electric night sight. An electric motor is provided for elevating and depressing. The time required to elevate or depress the gun through 12° is not to exceed 39 seconds. This motor, by a rocking pinion and lever, is also used for retracting. The time required for retracting is not to exceed 2 minutes 45 seconds. An electric motor is provided for traversing in either direction. This motor is required to traverse the carriage through 360° in 1 minute 30 seconds and permit of the gun being set to within 1 minute of arc.

298. Electric firing is arranged for by the use of a magneto-firing box, which is automatically cocked and arranged to be fired by the man on the left platform. The electric cables are so arranged that the circuit is complete only when the top carriage is forward against the stops or the gun is in full battery. Controllers, circuit breakers, and all adjuncts necessary for electric operation are located convenient to the man on the left platform.

299. *Steel forgings for cannon.*—All gun forgings except four for 6-inch rapid-fire guns ordered in June, 1902, have been completed. Excellent qualities have been shown in the tests of the nickel-steel forgings for the 3-inch B. L. rifle, model 1902.

BETHLEHEM STEEL WORKS.

300. The following work has been in progress during the fiscal year at the Bethlehem Steel Works, under the supervision of the inspector of ordnance at those works:

Twenty-five 5-inch R. F. guns, steel, model 1897. Twenty-four of these guns have been finished and shipped.

One 5-inch combined rapid-fire and disappearing gun and carriage under contract dated July 2, 1900. This gun, exclusive of the breech mechanism, may be considered as about 95 per cent completed. The carriage may be considered as about 85 per cent completed. The construction is by allotment by the Board of Ordnance and Fortification.

One 6-inch R. F. gun on pedestal mount. The jacket and muzzle hoops are assembled on the tube of this gun. The gun, exclusive of the breech mechanism, may be considered as about 40 per cent completed. The carriage may be considered as about 50 per cent completed. The construction is from allotment made by the Board of Ordnance and Fortification, dated January 3, 1901.

Ten and 12 inch B. L. rifles.—During the year five 10-inch rifles and three 12-inch rifles were completed and proved.

Seven sets of forgings for 6-inch R. F. gun, model 1900.—These forgings were all delivered by January 2, 1902.

Five sets of forgings for 12-inch B. L. rifle, model 1900.—These forgings were all delivered by January 22, 1902.

301. The deliveries during the year by the Bethlehem Steel Company are as follows:

15 sets of forgings	$271,133.73
4 10-inch B. L. rifles	143,421.25
3 12-inch B. L. rifles	160,470.53
24 5-inch R. F. guns	136,366.85
Total	711,392.36

302. Shipments made during the year were as follows:

Number.	Articles.	Weight.
	From the Bethlehem Steel Works.	*Pounds.*
24	5-inch R. F. guns	189,566
5	10-inch B. L. rifles	341,632
3	12-inch B. L. rifles	351,348
71	Forgings for 6-inch R. F. gun	188,514
33	Forgings for 10-inch B. L. rifle	300,826
59	Forgings for 12-inch B. L. rifle	861,612
2	Forgings for 12-inch B. L. R. mortars	1,090
3	Forgings for 16-inch B. L. R. gun	16,530
970	Miscellaneous castings for forgings	239,788
	Total	2,490,906
	From the Carpenter Steel Works.	
455	10-inch A. P. shot	308,115

303. *Works of the Driggs-Seabury Gun and Ammunition Company, Derby, Conn.*—Shipments of 6-pounder guns and carriages, and 15-pounder guns and mounts have been made as follows:

SIX-POUNDER GUNS AND MOUNTS.

Number.	Where shipped.	Date of shipment.
21-22	Fort Schuyler, N. Y	Nov. 22, 1901
23-24	Fort Wadsworth, N. Y	Do.
25-26	Fort Hamilton, N. Y	Do.
27-28	Fort at Sullivans Island, South Carolina	Do.
29-30	Fort Delaware, Del	Do.
31-32	Fort Du Pont, Del	Dec. 23, 1901
33	Washington Barracks, D. C	Jan. 13, 1902
34	Watervliet Arsenal, N. Y	Jan. 27, 1902
35-36	Fort Adams, R. I	Mar. 1, 1902
37-38	Fort Greble, R. I	Do.
39-42	Fort Terry, N. Y	Mar. 22, 1902
43-44	Fort Michie, N. Y	Do.
45-48	Fort H. G. Wright, N. Y	Apr. 17, 1902
49-50	Fort Wetherill, R. I	June 23, 1902

FIFTEEN-POUNDER GUNS AND MOUNTS.

81-84	Fort Rodman, Mass	June 27, 1902
85-86	Fort Monroe, Va	Do.
87-88	Fort Hamilton, N. Y	Do.

The following papers are submitted as appendices to this report.

Appendix I.—Report of the board for testing disappearing carriages (2 plates).

Appendix II.—Report of the commanding officer of Watertown Arsenal upon the test of gun steel containing streaks (12 plates).

Appendix III.—Report of Capt. Beverly W. Dunn, Ordnance Department, upon the establishment of a course of instruction for ordnance officers.

REPORTS OF THE ORDNANCE BOARD.

Appendix IV.—Competitive test of field artillery material (2 plates).

Appendix V.—Test of experimental shrapnel for 3-inch gun (10 plates).

Appendix VI.—Test of base percussion fuse for field, siege, and seacoast service (5 plates).

Appendix VII.—Methods of investigation and test of high explosives for the bursting charges of projectiles.

Appendix VIII.—Test of night sights for seacoast guns (1 plate).

Appendix IX.—Test of bar sight for 5-inch R. F. gun (3 plates).

Appendix X.—Test of telescopic sight with vertical and horizontal hairs.

Appendix XI.—Test of Zeiss stereoscopic binocular range finder (1 plate).

REPORTS FROM THE SPRINGFIELD ARMORY.

Appendix XII.—Test of Cole elliptical bore rifle.

Appendix XIII.—Test of latest model Mauser automatic pistol.

Very respectfully,

William Crozier,
Brigadier-General, Chief of Ordnance.

The Secretary of War.

APPENDIX I.

REPORT OF THE BOARD FOR TESTING DISAPPEARING CARRIAGES.

Report of a board which convened at Washington, D. C., July 22, 1902, pursuant to the following orders:

SPECIAL ORDERS, No. 166.

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, July 16, 1902.

[Extract.]

1. By direction of the Secretary of War, and to carry out the following provisions of the act making appropriations for fortifications and other works of defense, etc., approved June 6, 1902, "for purchase, manufacture, alteration, and issue of carriages for mounting seacoast guns of eight, ten, and twelve inch calibers, including any new tools or machinery necessary for their manufacture at arsenals, two hundred and fifty thousand dollars: *Provided*, That no money appropriated by this act shall be expended for disappearing carriages or emplacements or magazines therefor until a thorough test has been made by a disinterested board of officers of high rank and at least one mechanical engineer of high standing, with not less than thirty shots from a ten-inch gun, under all the conditions of actual service, the whole time elapsing between the firing of the first shot and the firing of the last shot being recorded, and also the time elapsing between the firing of each shot in succession, the cost of such test to be paid out of this appropriation." A board of officers to consist of—

Col. Wallace F. Randolph, Chief of Artillery;
Capt. Eugene H. C. Leutze, U. S. Navy, detailed for that purpose by the Secretary of the Navy;
Maj. John G. D. Knight, Engineer Corps;
Maj. Charles Shaler, Ordnance Department;
Maj. Albert S. Cummins, Artillery Corps;
Maj. Benjamin H. Randolph, Artillery Corps, and
Mr. John R. Freeman, of Providence, R. I.,

is hereby appointed to meet at Washington, D. C., on Tuesday, July 22, 1902, at 10 o'clock a. m., or as soon thereafter as practicable, to conduct certain tests of disappearing gun carriages. The board will be governed by the provisions of the statute and supplementary instructions to be communicated to the president thereof by letter. Such journeys as may be required of the officers named in attending the meetings of the board and in returning to their proper stations are necessary for the public service.

*　　*　　*　　*　　*　　*　　*

By command of Lieutenant-General Miles:

H. C. CORBIN,
Adjutant-General, Major-General, U. S. Army.

SPECIAL ORDERS, No. 167.

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, July 17, 1902.

*　　*　　*　　*　　*　　*　　*

15. By direction of the Secretary of War, Capt. Richmond P. Davis, Artillery Corps, is detailed as recorder of the board of officers appointed by paragraph 1, Special Orders, No. 166, July 16, 1902, from this office. Such journeys as are required of Captain Davis in obeying this order are necessary for the public service.

*　　*　　*　　*　　*　　*　　*

By command of Lieutenant-General Miles:

H. C. CORBIN,
Adjutant-General, Major-General, U. S. Army.

SPECIAL ORDERS, No. 174.

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, July 25, 1902.

* * * * * * *

9. By direction of the Acting Secretary of War, Capt. William H. Coffin, Artillery Corps, is detailed as a member of the board of officers appointed by paragraph 1, Special Orders, No. 166, July 16, 1902, from this office, vice Maj. Benjamin H. Randolph, Artillery Corps, hereby relieved. Such journeys as may be required in attending the meetings of the board and returning to his proper station are necessary for the public service.

* * * * * * *

By command of Lieutenant-General Miles:

WM. C. CARTER,
Brigadier-General, U. S. Army, Acting Adjutant-General.

WASHINGTON, D. C., *July 22, 1902.*

Pursuant to the foregoing orders the board met in the rooms of the Board of Ordnance and Fortification at 10.20 a. m.

Present: Col. Wallace Randolph, Chief of Artillery; Capt. Eugene H. C. Leutze, U. S. Navy; Maj. John G. D. Knight, Engineer Corps; Maj. Charles Shaler, Ordnance Department; Maj. Albert S. Cummins, Artillery Corps; Mr. John R. Freeman, of Providence, R. I., and Capt. Richmond P. Davis, Artillery Corps, recorder. Absent: Maj. Benjamin H. Randolph, Artillery Corps.

The board then proceeded to business, and the following letter from the office of the Adjutant-General was laid before it:

WAR DEPARTMENT, ADJUTANT-GENERAL'S OFFICE,
Washington, July 16, 1902.

SIR: I am directed by the Secretary of War to inclose copy of paragraph 1, Special Orders, No. 166, July 16, 1902, from this office, appointing a board of officers, of which you are president, to meet at Washington, D. C., on Tuesday, July 22, 1902, for the purpose of conducting certain tests of the disappearing-gun carriages.

This board is appointed pursuant to the following provision of the act making appropriations for fortifications and other works of defense, etc., approved June 6, 1902: "For purchase, manufacture, alteration, and issue of carriages for mounting seacoast guns of eight, ten, and twelve inch calibers, including any new tools or machinery necessary for their manufacture at arsenals, two hundred and fifty thousand dollars: *Provided*, That no money appropriated by this act shall be expended for disappearing carriages or emplacements or magazines thereof until a thorough test has been made by a disinterested board of officers of high rank and at least one mechanical engineer of high standing, with not less than thirty shots from a ten-inch gun, with full charges of smokeless powder and full weight of shot, under all the conditions of actual service, the whole time elapsing between the firing of the first shot and the firing of the last shot being recorded, and also the time elapsing between the firing of each shot in succession, the cost of such test to be paid out of the appropriation."

The Secretary of War directs that the board make a thorough test, by firing under ervice conditions, of the following types of carriages, viz:

6-inch nondisappearing.
6-inch disappearing.
8-inch nondisappearing.
8-inch disappearing.
10-inch nondisappearing.
10-inch disappearing.
12-inch nondisappearing.
12-inch disappearing.

The test will include the following firing:

As many rounds, fired deliberately from a carriage of each type, as the board may consider necessary for its satisfaction as to the operation of the material.

Ten rounds from a carriage of each type, to be fired as rapidly as possible, the time required for the firing to be taken.

Thirty rounds from a 10-inch carriage of each type, to be fired as rapidly as possible, under all the conditions of actual service, the whole time elapsing between the

firing of the first shot and the firing of the last shot being recorded, and also the time elapsing between the firing of each shot in succession.

All the firing, except such rounds as the board may wish for its information on any point, will be from carriages of the latest model installed, and with full service charges of smokeless powder and projectiles of full weight.

The board will report as to the general efficiency and adaptability for use in the service of the disappearing carriage of the type now installed, known as the Buffington-Crozier carriage, and as to the class of site, if any, upon which such carriages should be emplaced.

The Chief of Ordnance has sent ammunition as follows:

To Fort Monroe, Va.:
  Fifteen full-charge rounds for 8-inch B. L. rifle.
To Fort Du Pont, Del.:
  Fifteen full-charge rounds for 8-inch B. L. rifle.
  Fifteen full-charge rounds for 12-inch B. L. rifle.
To Fort Wadsworth, N. Y.:
  Fifteen full-charge rounds for 6-inch B. L. rifle.
To Sandy Hook Proving Ground, New Jersey:
  Forty-five full-charge rounds for 10-inch B. L. rifle.
To Fort H. G. Wright, N. Y.:
  Fifteen full-charge rounds for 6-inch B. L. rifle.
  Forty-five full-charge rounds for 10-inch B. L. rifle.
  Fifteen full-charge rounds for 12-inch B. L. rifle.

The board will visit each of the posts above named and upon conclusion of its work at these posts will reassemble at Washington, D. C., for the preparation of its report, and upon conclusion of this duty the members will return to their proper stations.

The commanding general of the Department of the East and the chiefs of the various staff departments will give instructions such as to insure the affording of all necessary facilities to the board for the discharge of the duty which is imposed upon it, and the Chief of Engineers and the Chief of Ordnance will furnish it with all the information which it may need.

It will be borne in mind that the object of these tests is to determine the absolute and relative serviceability of the disappearing carriage, and all elements not contributing toward the required determination will be eliminated.

As much expedition as is consistent with the proper and thorough performance of the duty is enjoined.

Very respectfully, H. C. CORBIN,
Adjutant-General, Major-General, U. S. Army.

Col. WALLACE R. RANDOLPH,
Chief of Artillery, U. S. Army.

The board then considered its letter of instructions and decided to proceed at once to the business mentioned therein.

The important results of the tests are given in the following table; the full records are given in the appended tables, I to XIV.

[D. C. is for disappearing carriage; N. D. C. is for nondisappearing carriage.]

Gun and mount.	Average interval between rounds.	Shortest interval between rounds.	Remarks on the action of the carriage.
	′ ″	′ ″	
6-inch B. L. rifle on D. C., model 1898, at Fort H. G. Wright; series of 10 shots.	0 25.1	0 24.5	Worked perfectly.
6-inch B. L. rifle on D. C., model 1899, at Fort H. G. Wright; series of 10 shots.	0 20	0 16	Do.
6-inch B. L. rifle on N. D. C. (Armstrong), at Fort Wadsworth; series of 10 shots.	0 17.1	0 14	Elevation changed about 15′ at each shot after adjustment of carriage, and it was necessary for the gunner to hold the wheel to prevent loading movements from changing the azimuth of the piece.
8-inch B. L. rifle on D. C., model 1896, at Fort Du Pont, Del., series of 10 shots.	1 28.3	1 15	When tripped the carriage did not reach the firing position by distances varying from three-fourths to one-half inch, and had to be embarred into battery before firing. It stopped 9¼ inches from the firing position when the rails were sanded; could only be embarred 8 inches forward, and was fired 1¼ inches from battery.

[D. C. is for disappearing carriage; N. D. C. is for nondisappearing carriage.]

Gun and mount.	Average interval between rounds.	Shortest interval between rounds.	Remarks on the action of the carriage.
	′ ″	′ ″	
8-inch B. L. rifle on N. D. C., model 1892, at Fort Monroe, Va.; series of 10 shots.	1 32	1 9	After adjustment worked perfectly except for 1 shot, when it stopped one-half inch from firing position.
10-inch B. L. rifle on D. C., model 1898, at Fort H. G. Wright; series of 10 shots.	1 38.3	1 14	Carriage worked perfectly.
10-inch B. L. rifle on D. C., model 1898, at Fort H. G. Wright; series of 30 shots.	....	....	Action of carriage perfect, but series was stopped on eighteenth round, due to failure of gas-check pad.
10-inch B. L. rifle on D. C., model 1898, at Fort H. G. Wright; series of 30 shots.	0 54.3	0 47	1½ gallons of oil taken out of cylinders; carriage worked perfectly. One detachment fired all the rounds.
10-inch B. L. rifle on N. D. C., model 1893, at Sandy Hook Proving Ground; series of 10 shots.	1 47.3	1 25.4	Carriage did not run quite into firing position; the distances varied from 1 to one-half inch. This was a carriage used for experimental purposes at the proving ground.
10-inch B. L. rifle on N. D. C., model 1893, at Sandy Hook Proving Ground; series of 30 shots.	1 36.4	1 6.4	Carriage worked well, but occasionally stopped a small distance from the firing position. Oil squirted from throttling-bar bolts after fifth round, but the recoil was not materially affected. Three detachments required for the 30 rounds.
12-inch B. L. rifle on D. C., model 1897, at Fort H. G. Wright; series of 10 shots.	....	....	Throttling pipe burst on carriage No. 22 on first round, and on carriage No. 21 on fourth round.
12-inch B. L. rifle on D. C., model 1897, at Fort H. G. Wright; series of 10 shots.	0 58.1	0 55.2	3 gallons of oil were taken out of the cylinders. The throtling pipes of carriage No. 21 had been replaced by new ones. The carriage worked perfectly.
12-inch B. L. rifle on N. D. C., model 1892, at Fort Du Point, Del.; series of 10 shots.	3 24.7	2 58	Carriage worked perfectly except for slight leakage of oil from filling plug of one cylinder and head of other cylinder.

The carriages were carefully inspected both before and after each series of firing, and each deliberate round.

After the first shot with the nondisappearing carriage for the 8-inch B. L. rifle the carriage remained 39.5 inches from the firing position. Upon inspection no leakage of oil was found, but the followers (or glands) were so tightly screwed home that four men on the wrenches could not loosen them. Twelve threads of one and eleven of the other were exposed to view. Both were finally loosened by means of power and gently screwed home. The carriage was then run into battery, whereupon oil oozed from the rear end of the right cylinder. This latter was due to the leakage of air into the cylinder while the gun was from battery on account of the vacuum produced by the withdrawal of the piston rod. The filling plug of the cylinder was opened and the oil squirted up as though under a pressure equivalent to a hydrostatic head of 5 feet. About a quart of oil was added through the filling plug of the left cylinder and was found to be properly equalized between the two cylinders. The firing was then continued, and the table shows that no more trouble was experienced.

The only breakage during the tests were the two throttling pipes of the disappearing carriages for the 12-inch B. L. rifle. The photograph (fig. 1) shows the broken pieces. The hole on pipe 1 has been somewhat opened for inspection and a distinctly laminated structure is clearly seen.

The board completed the tests at Fort H. G. Wright August 12, 1902, and adjourned to meet at Washington, D. C., to prepare its report:

WASHINGTON, D. C., *August 13, 1902.*

The board met at 10 o'clock a. m.

Present: All the members and the recorder.

The board then proceeded to consider in detail the following in their relation to the merits of the two types of carriage, to wit: Site; rapidity of fire; exposure of men; exposure of gun and vulnerability of mount; liability to derangement of carriages considered as machines; derangement of base; failure to go completely into battery; comparative cost; target practice; premature discharge; adaptability to quick direct laying; height of gun in battery above base of emplacement; blast.

MATTERS OF FACT AND CONCLUSIONS OF THE BOARD CONCERNING THE ENUMERATED ELEMENTS WHICH INFLUENCE THE SELECTION OF THE TYPE OF CARRIAGE.

Site.—The elevation of the site above the sea level does not materially affect the choice of the style of carriage to be mounted.

Rapidity of fire.—With the larger guns, 10 and 12 inch calibers, greater rapidity of fire was obtained with the disappearing type. The advantage in time and less fatigue of men are sufficient to justify a decided preference for the disappearing mount. With the 8-inch gun the rapidity of working by men of equal skill would appear to be substantially the same, though the labor would be greater for the nondisappearing type. With the 6-inch gun the advantage was decidedly in favor of the nondisappearing carriage.

Curves showing the relative rapidity of fire and time involved in the various operations of loading are given in Table XIV.

Exposure of men.—With the nondisappearing carriage without shield substantially every man working the gun, except those on the elevating cranks, is exposed to direct fire, while with the disappearing carriage and direct laying only one is exposed, and with indirect laying no one is exposed for small angles of fall. With the nondisappearing Armstrong carriage with shield the gunner has better protection than he has on any other mount examined by the board.

These points are well illustrated by the accompanying photographs:

Exposure of gun and vulnerability of mount.—The gun on a nondisappearing carriage is exposed at all times, while with the disappearing carriage it is exposed at each fire with direct laying about seven seconds plus part of the few seconds required for aiming. When the gun on a disappearing mount is laid indirectly it is exposed only about seven seconds at each firing. To direct fire the vulnerability of the disappearing carriage is greater than that of the nondisappearing during equal times of exposure, but the time of exposure of the disappearing type is insignificant relative to that of the nondisappearing.

The disappearing mount is more vulnerable to fragments of shell, concrete, sand, etc., falling inside of the angle of protection by reason of the character and the greater number of working parts.

Figures 7, 8, 9, and 10 illustrate these points.

Liability to derangement of carriages considered as machines.—Considering the two mounts merely as machines, the disappearing contains more moving parts and appears more susceptible to mechanical derangement, but the extent of this additional complication is measured chiefly by the addition of counterpoise weight, vertical crosshead guides, tripping device, the two gun levers, two additional pairs of trunnions, and the additional weight imposed on the base.

Both carriages contain parts of substantially equal complication in hydraulic cylinders with pistons, piston rods, throttling bars, and equalizing pipes, and the rollers on which the carriage moves into battery are not necessarily more complicated in one type than in the other. The traversing mechanism and the gearing and auxiliary mechanism by which the gun is pointed at the proper angle of elevation appear little, if any, more liable to derangement in one type than in the other.

It is to be noted that the pressure in the recoil cylinders and equalizing pipes of the nondisappearing carriages is greater than in those of the disappearing type.

Certain experiments made by the board with sand scattered over the chassis rails of both types of carriage showed that the mechanism of the disappearing carriage as now constructed was more susceptible to such obstruction.

The mechanical differences of the two types of mount are not in themselves sufficient to determine the choice of type.

Interference with action by derangement of platform or base.—Liability to derangement from this cause is, in the opinion of the board, greater in disappearing mounts. The board, however, has had no opportunity of observing this derangement, but it is of the opinion that it is of remote probability with the latest type of installation, except on sites where the foundation may be unstable.

Derangement of aim by failure to go into battery.—The advantage is materially with the nondisappearing mount; with the latest type of carriage no such failure occurred during the tests of the board. (See Table XIII.)

Comparative cost.—As between the nondisappearing carriage without shield and disappearing carriage there does not appear to be sufficient difference in cost of emplacement and mount to materially influence the choice. With the proper shield added to the standard United States nondisappearing mount, it appears that the cost would equal or more probably exceed that of the disappearing.

Target practice.—Under service conditions with full charges of smokeless powder the two types of mount are equally suitable. The nondisappearing is much better adapted to subcaliber practice and firing with reduced charges.

Premature discharge.—A premature discharge of a gun on a disappearing carriage while below the parapet would be far more disastrous to the mount and men serving the gun than would be the case with premature discharge of a gun on a nondisappearing carriage. When a lanyard is used for firing the act of the disappearing gun in rising into battery increases the liability to premature discharge by the possible fouling of the lanyard, except in the case of the 6-inch gun with short lanyard of the latest firing device.

Effect of blast on neighboring gun detachment when firing toward the flank of a battery.—The interference with the neighboring detachment would be much more serious with the nondisappearing type of carriage.

Adaptability to quick, direct aiming.—Neither style of carriage has any decided advantage.

Comparison of mounts for 6-inch rapid-fire gun.—The disappearing mount is believed to be less advantageous than the shielded pedestal mount for this purpose because of its slower rate of firing, its lack of protection to the gunner, its slower aiming when following a rapidly moving torpedo boat, and because of a belief that in quick work at

short range the men will be encouraged and their efficiency increased by opportunity to observe the action.

After consideration of the various questions involved, the board recommends the continuance of the manufacture of the disappearing carriages for mounting guns of 8, 10, and 12-inch calibers, irrespective of site, and the suspension of the manufacture of disappearing carriages for guns of 6-inch caliber.

WALLACE F. RANDOLPH,
Chief of Artillery, President.
E. H. C. LEUTZE,
Captain, U. S. Navy.
JOHN G. D. KNIGHT,
Major, Corps of Engineers, U. S. Army.
CHARLES SHALER,
Major, Ordnance Department, U. S. Army.
ALBERT S. CUMMINS,
Major, Artillery Corps, U. S. Army.
WM. H. COFFIN,
Captain, Artillery Corps, U. S. Army.
JOHN R. FREEMAN,
Civil and Mechanical Engineer.
RICHMOND P. DAVIS,
Captain, Artillery Corps, U. S. Army, Recorder.

WASHINGTON, D. C., *August 16, 1902.*

Approved: September 18, 1902.

ELIHU ROOT,
Secretary of War.

SUPPLEMENTAL REPORT.

The members of the board for testing gun carriages during its experiments for that purpose observed several matters which will materially increase the efficiency of the service if they receive due consideration by the proper authorities. The board therefore submits the following supplemental report, containing its observations and conclusions on several points suggested by its tests:

INCREASED COMPENSATION FOR GUNNERS.

As no action can be successful without good gunners, it is essential that men of intelligence be secured for that position. This can only be done by giving higher wages than at present prevail, else such men can not be attracted to the service. This fact is recognized in determining the pay and allowances of gun captains in the Navy. Chief gun captains receive $50 and one ration, first-class gun captains $40 and one ration, and second-class gun captains $35 and one ration.

TARGET FIRING.

We find that the artillery has very little target practice in firing guns under service conditions, namely, with full charges. This is

fatal to efficiency. Experience can not be gained with a machine, such as a modern gun, without practice. Practice with less than full charges is worse than useless, as it gives wrong impressions and does not test the machines, thereby engendering false confidence. Aiming can be taught in a great measure by subcaliber practice. We therefore recommend abandoning practice with reduced charges, substituting subcaliber practice therefor, and asking for appropriations large enough to enable each company of coast artillery to have annually at least 15 rounds for target practice with full service charges.

NECESSITY FOR SKILLED MECHANICS.

The completion of the scheduled firings was expedited by the assistance of officers and mechanics of the Ordnance Department. The necessity for their cooperation accentuates the prominent need in the Artillery Corps of men qualified to meet emergencies in the operation of such scientific instruments as the ordnance of to-day. Such men must be mechanics of high grade and can not be attracted to the Army by rates of pay which will hardly satisfy skilled labor.

The need of greater skill in and higher rates of pay for mechanics of artillery than are now received is indicated.

After these men are secured for the Army, they should receive a thorough course of instruction in the details of their respective duties.

PROTECTION FOR THE GUNNER.

The disappearing gun carriage admits of cover against direct fire to all the gun detachment except the gunner, who must be exposed while aiming. Upon this man ultimately depends the success of artillery fire. He is trained and encouraged to develop the peculiar characteristics which make the efficient gunner, yet at the time when most depends upon his services he is most liable to injury.

A light and inconspicuous shield (possibly movable) for his exposed post would greatly diminish this liability.

MANUAL FOR THE SERVICE.

Several differences in the care and manipulation of the guns were noted—differences in the practice of the artillery officers and in that of artillery and ordnance officers. Some of these arose from greater and later experience.

A manual based upon the latest and best experience of officers of both ordnance and artillery should be prepared and issued, and some source should be determined from which should issue at intervals to officers memoranda giving the changes in the manual for the care and use of guns and mounts.

CONCEALMENT OF BATTERIES.

The appearance of batteries should be viewed from points which an enemy might occupy. Where crest lines and slopes are then visible, they should be concealed wherever practicable by planting trees to the rear and shrubbery to the front and on slopes. In the absence of trees and shrubbery in the vicinity of batteries, these plantings might in themselves aid to locate battery sites; hence random planting in such places might be advisable.

CHARACTER OF CONCRETE.

The fracture of the concrete of superior slopes near the exterior crest makes apparent the necessity of strictly monolithic concrete construction of parapets in sections as wide and deep as practicable.

Superior slopes should be finished with layers of concrete superimposed upon the concrete which has taken its initial set, unless such layers are as thick as practicable, having regard to voids due to magazines and passageways.

PROTECTION OF MECHANISM AGAINST SAND AND FRAGMENTS THROWN BY EXPLODING SHELLS, ETC.

The board recommends that attention be given to devising and supplying detachable shields or other appropriate means for preventing the obstruction of the rollers and chassis rails of the disappearing carriage, and for shielding gear teeth. It is also recommended that the piston rods be so attached to the chassis that freedom of movement into battery will not be prevented by a moderate amount of sand on the rails.

IMPROVED LOADING APPLIANCES FOR NONDISAPPEARING CARRIAGE.

The board recommends that study and experiment be directed to improving and supplying these, and lessening the fatigue now incident to rapid working of a gun on this carriage.

Attention should be given to suitable shields for the protection of the detachment, and the board is of the opinion that the nondisappearing carriages are susceptible of much improvement.

MANUAL TRAVERSING AND ELEVATING BY THE GUNNER.

The board attaches great importance to the necessity for increased facility in direct aiming and manual operations, and recommends that careful study be given to the possible improvement of the present mechanism so as to lessen friction and increase rapidity of following, and that attachments for manipulation by electric power be so made that they can instantly be thrown out of connection in case of failure to operate properly.

Attention is directed to the possibility of a more open and conspicuous graduation and marking of the azimuth circles, and especially of the elevating circles, so that angles may be plainly visible to the gun commander and the men at the cranks.

GAS CHECKS.

In the tests witnessed by the board the gas-check pads for both 10 and 12 inch guns failed; the failure caused the suspension of firing with a 10-inch gun at Fort H. G. Wright after the twenty-eighth round on July 29, and the pad became so injured on August 12 that it required the constant attention of an ordnance officer during the last few rounds of a series of thirty shots.

With the 12-inch gun the gas-check pad failed after the twelfth round, so that the breech could not be closed.

The board therefore recommends that further study be given to the construction of the pad and its appurtenances, and that a supply of extra pads form a part of the equipment of each gun.

MECHANISM OF THE BUFFINGTON-CROZIER CARRIAGE.

The board desires to record its opinion that the general mechanical principles involved in the chief elements and movements of the Buffington-Crozier disappearing carriage are admirably adapted to their purpose.

WALLACE F. RANDOLPH,
Chief of Artillery, President.
E. H. C. LEUTZE,
Captain, U. S. Navy.
JOHN G. D. KNIGHT,
Major, Corps of Engineers, U. S. Army.
CHARLES SHALER,
Major, Ordnance Department, U. S. Army.
ALBERT S. CUMMINS,
Major, Artillery Corps, U. S. Army.
WM. H. COFFIN,
Captain, Artillery Corps, U. S. Army.
JOHN R. FREEMAN,
Civil and Mechanical Engineer.
RICHMOND P. DAVIS,
Captain, Artillery Corps, U. S. Army, Recorder.

WASHINGTON, D. C., *August 16, 1902.*

Approved.

E. R.

TABLE I.—*Record of firing at Fort H. G. Wright, July 29 and 30, 1902, to test the disappearing carriage for 6-inch B. L. rifle.*

[Carriage No. 24, model 1898.]

JULY 29.

No. of fire.	Time of firing.	Interval between shots of series.	Total time between first and last shot of series.	Average interval between shots of series.	Remarks on action of carriages.	General remarks.	Special remarks.	Ammunition.	Quadrant elevation before firing.	Recoil in notches
	h. m. s.	m. s.	m. s.	s.					° ′	
1	1 39 4	....	....	....	Worked perfectly..	Both shells burst.	Fired by electricity. Ammunition was served from hoist about 54 feet from piece. The detachment was fairly efficient and consisted of 3 noncommissioned officers and 20 privates. Two defective primers caused a delay of 1 minute 20 seconds; 15½ seconds were lost in traversing and 10 seconds in locking, making a total of 105.5 seconds lost. Single motion breech mechanism operated by a lever.	Full service charge of smokeless powder, 26 pounds, lot 1, 1899, Du Pont; I. V. 2650; P. 31,600; nitroglycerine. Service cast-iron shell, unfilled.	6 34	15
2	1 53 26	....	....	....	.....do........				6 34	18

JULY 30.

No. of fire.	Time of firing.	Interval between shots of series.	Total time between first and last shot of series.	Average interval between shots of series.	Remarks on action of carriages.	General remarks.	Special remarks.	Ammunition.	Quadrant elevation before firing.	Recoil in notches
3	9 46 7	....	....	....	Worked perfectly..	Fired to sea with changes of elevation and azimuth. Nearly all the shells burst.	Fired by electricity. Ammunition was served from hoist about 54 feet from piece. The detachment was fairly efficient and consisted of 3 noncommissioned officers and 20 privates. Two defective primers caused a delay of 1 minute 20 seconds; 15½ seconds were lost in traversing and 10 seconds in locking, making a total of 105.5 seconds lost. Single motion breech mechanism operated by a lever.	Full service charge of smokeless powder, 26 pounds, lot 1, 1899, Du Pont; I. V. 2650; P. 31,600; nitroglycerine. Service cast-iron shell, unfilled.	6 45	16
4	9 48 16	Firs shot of series for rapidity.			.....do........				6 40	15
5	9 48 55.5	0 39.5	^{a}5 31.5 (3 46)	25.1	.....do........				7 0	14
6	9 49 20.5	0 25			.....do........				6 30	13
7	9 49 45	0 24.5			.....do........				6 45	17
8	9 50 9	0 24			.....do........				6 0	15
9	9 50 38	0 29			.....do........				6 30	14
10	9 51 6	0 28			.....do........				7 0	16
11	9 51 44	0 38			.....do........				7 30	18
12	9 53 22	1 38			.....do........				7 0	19
13	9 53 47.5	0 25.5			.....do........				7 45	17

^{a} Lost time from column of "Special remarks" is 105.5 seconds; hence corrected elapsed time is 3 minutes 46 seconds.

TABLE II.—*Record of firing at Fort H. G. Wright, August 12, 1902, to test the disappearing carriage for 6-inch B. L. rifle.*

[Carriage No. 26, model 1898.]

No. of fire.	Time of firing.	Interval between shots of series.	Interval between first and last shot of series.	Average interval between shots of series.	Remarks on action of carriage.	General remarks.	Special remarks.	Ammunition.	Quadrant elevation.	Recoil in notches
	h. m. s.	s.		s.					° ′	
1	1 34 31				Worked perfectly				7 40	20
2	1 35 42	First of series for rapidity			do				7 50	20
3	1 36 10.6	28.6			do				7 50	20
4	1 36 26.6	16	Lost 25		do	The shells were provided with brass base plugs, instead of lead ones, as previously. Fired to sea, with changes in azimuth. One quart of oil removed from cylinders. Temperature of oil in cylinder at start, 87.5°; at end, 97.5°.	Fired by electricity. The detachment was fairly efficient and consisted of 8 noncommissioned officers and 20 privates. Lost 25 seconds, due to defective primer. Single motion breech mechanism worked by lever.	Full service charge of smokeless powder, lot 1, 1899, Du Pont; I. V. 2,650; P. 31,600; nitroglycerine. Cast-iron shell, unfilled; served from hoist about 54 feet from piece.	7 50	19
5	1 37 11.6	45			do				7 50	20
6	1 37 32.6	21	a179.8 s.	20.1	do				7 50	19
7	1 37 53.4	20.8			do				7 50	20
8	1 38 10.6	17.2			do				7 50	19
9	1 38 30.6	20			do				7 50	19
10	1 38 49.6	19			do				7 50	20
11	1 39 6.8	17.2 Last of series			do				7 50	20
12	1 43 50	Extreme elevation			do				15 0	18

a204.8—25 seconds.

TABLE III.—*Record of firing at Fort Wadsworth, New York Harbor, July 26, 1902, to test pedestal mount for 6-inch R. F. B. L. rifle.*

[Carriage No. 11169.]

No of fire.	Time of firing.	Interval between shots of series.	Total time between first and last shot of series.	Average interval between shots of series.	Remarks on action of carriage.	General remarks.	Special remarks.	Ammunition.	Quadrant elevation.	Estimated recoil.
	h. m. s.	*s.*	*m. s.*	*s.*					° ′	*Ins.*
1	11 55 0	....	....	....	Elevation changed from 8° 10′ to 11°.	Rounds 1 and 2 fired at fixed target. Fired all subsequent shots to sea. Firing was interrupted at round 5 by defective preparation of ammunition (an adapter not being screwed home) and by shipping, causing an apparent loss of 18 minutes 33.9 seconds time between fifth and sixth shots. Single motion breech mechanism worked by a lever.	Elevating clutch screwed up after first shot, and it changed only about 15 minutes for subsequent rounds. It was necessary for the gunner to hold the wheel during the firing to prevent loading movements from changing azimuth of piece. The detachment serving the piece had never drilled at it before. The projectiles were served from steps of platform about 10 feet from piece, and powder from a magazine about 40 feet from the piece. Percussion primers were used.	Full service charge of cordite in a metallic case. Unfilled service shell.	8 10	11-10
2	12 10 55	....	....	....	Elevation changed about 15′.				8 10	11-10
3	12 15 48.5	First of series for rapidity			.....do				8 10	11-10
4	12 16 9.5	21			.....do				8 10	11-10
5	12 16 28.5	19			.....do				8 10	11-10
6	12 35 19.5	a 17.1 equals 18′ 51″ less 18′ 33.9″.			.....do				8 10	11-10
7	12 35 36	16.5	2 33.5	17.1	.....do				8 10	11-10
8	12 35 50	14			.....do				8 10	11-10
9	12 36 08	18			.....do				8 10	11-10
10	12 36 25	17			.....do				8 10	11-10
11	12 36 41	16			.....do				8 10	11-10
12	12 36 56	15 Last of series for rapidity			.....do				8 10	11-10

a The total interval between the fifth and sixth shots was 18 minutes 51 seconds; 17.1 seconds being the average interval to be supplied, leaves 18 minutes 33.9 seconds as the lost time between the shots.

The two intervals for the first three shots give 40 seconds, and the six for the last seven give 96.5 seconds. $\frac{40+96.5}{8}$=average interval for both series=17.1 seconds to be supplied between fifth and sixth.

TABLE IV.—*Record of firing at Fort Du Pont, Del., July 25, 1902, to test the disappearing carriage for 8-inch B. L. rifle.*

[Carriage No. 13, model 1896.]

No. of fire.	Time of firing.	Interval between shots of series.	Total time between first and last shot of series.	Average interval between shots of series.	Remarks on action of carriage.	General remarks.	Special remarks.	Ammunition.	Quadrant elevation before firing.	Recoil in notches.
	h. m. s.	m. s.	m. s.	m. s.					° ′	
1	11 08 30	....	....	....	Stopped short of firing position by distances varying from ⅜ to ¼ inch.	Fired at fixed target....		Full service charge of smokeless powder, 72 pounds, lot 1, 1900, Du Pont, serial No. 10: I. V. 2, 250: nitrocellulose; gran. 109; pres. 36,500. Service cast-iron shot; weight 300 pounds.	4 57	19
2	11 17 25	....	....	....	.....do	.....do	Added 23 pounds of counterweight after second shot. Changed throttling valve on seventh shot. The projectiles and powder were served from the hoist whose shaft was about 33 feet from the gun. The detachment was generally inefficient, and in two noticeable instances lost 10 seconds and 30 seconds by fouling the lanyard and unnecessary delay in changing azimuth. It consisted of 3 noncommissioned officers and 16 privates. The carriage was inspected and put in order by an expert one month before the test.		5 9.5	20
3	11 23 10	First of series for rapidity....			.....do	Changed azimuth			6 0	20
4	11 24 55	1 45			.....do	.....do			6 0	21
5	11 26 30	1 45			.....do	Azimuth same as for fourth.			7 0	21
6	11 28 0	1 30			.....do	.....do			7 0	21
7	11 29 22	1 22			.....do	.....do			8 0	19
8	11 31 20	1 58	*a*13 55	1 28.3	.....do	.....do			8 0	18
9	11 32 30	1 10			.....do	.....do			9 0	19
10	11 34 30	2 0			.....do	Changed to target......			5 30	19
11	11 35 50	1 20			.....do	Changed azimuth			10 0	19
12	11 37 5	1 15 Last of series for rapidity			.....do	.....do			11 0	19
13	11 46 41	....	....	....	Stopped short of firing position by distances varying from 9¼ to ¼ inches and fired 1¼ inches.	Changed azimuth. Maximum elevation and sanded rails.			12 0	13

a 40 seconds were lost due to gross work on the part of the detachment giving 13 minutes and 15 seconds as the corrected elapsed time from which 1 minute and 28.3 seconds is obtained.

TABLE V.—*Record of firing at Fort Monroe, Va., July 24, 1902, to test the nondisappearing carriage for 8-inch B. L. rifle.*

[Carriage No. 7, model 1892.]

No. of fire.	Time of firing.	Interval between shots of series.	Total time between first and last shot of series.	Average interval between shots of series.	Remarks on action of carriage.	General remarks.	Special remarks.	Ammunition.	Quadrant elevation.	Recoil.
	h. m. s.	m. s.	m. s.	m. s.					° ′	Ins.
1	10 40 35	....	....	....	Remained 39.5 inches from the firing position.	Fired at moving target.	The projectiles were served from the floor of the loading platform, about 10 feet from the piece. The powder was served from a magazine about 48 feet from the gun and 20 feet lower in level. The detachment serving the piece was well drilled, and consisted of 3 noncommissioned officers and 14 privates. The carriage had been overhauled by an expert three weeks before the firing.	Full servic charge of smokeless powder, 72 pounds, lot 1, 1900, Du Pont, serial No. 10; I. V. 2,250; P. 36,500; nitrocellulose; granulation, 109. Service cast-iron shot; weight, 300 pounds.	4 39	39.5
2	11 6 5	First of series for rapidity			Action perfect	....do			2 40	37.5
3	11 8 6	2 1			....do	....do			2 30	37
4	11 9 43	1 37			....do	....do			2 20	37.5
5	11 11 22	1 39			....do	....do			2 20	37
6	11 13 2	1 40			....do	....do			3 43	37.25
7	11 14 34	1 32	13 52	1 32	....do	Shifted to a stationary target.			2 50	37.5
8	11 16 16	1 42			....do	Fired at the stationary target.			2 30	38
9	11 17 25	1 9			....do	Shifted to the moving target.			2 20	37.5
10	11 18 44	1 19			....do	Fired at the moving target.			2 40	37
11	11 19 57	1 13 Last of series for rapidity			Remained half an inch from firing position.	....do			3 5	37.5
12	11 37 0	....	....	....	Action perfect	Fired with extreme elevation.			17 10	37.5
13	11 46 15	....	....	....	....do	Fired with sanded rails.			3 50	37.5

TABLE VI.—*Record of firing at Fort H. G. Wright, August 12, 1902, to test the disappearing carriage for 10-inch B. L. rifle.*

[Carriage No. 54, model 1898.]

No. of fire.	Time of firing.	Interval between shots of series.	Total time between first and last shot of series.	Average interval between shots of series.	Remarks on carriage.	General remarks.	Special remarks.	Ammunition.	Quadrant elevation.	Recoil in notches.
	h. m. s.	s.		s.					° ′	
1	8 38 40								6 0	17
2	8 54 10								8 0	17
3	8 58 5	First shot of series for rapidity.							6 45	17
4	8 59 2	57							7 0	15
5	8 59 55.4	53.4							7 20	13
6	9 0 53.8	58.4							6 40	15
7	9 1 43	49.2							6 55	16
8	9 2 35.2	52.2	40 s. lost						7 32	16
9	9 4 4.4	89.2							7 45	14
10	9 5 10.4	66							6 0	17
11	9 5 57.6	47.2							7 0	16
12	9 6 46.9	49.3							7 20	17
13	9 7 49.9	63							7 0	13
14	9 8 37.1	47.2							8 0	13
15	9 9 37.3	60.2	27 m. 35.3 s.	54.3a	1¼ gallons of oil were removed from the cylinders, and the carriage worked perfectly for every shot. The throttling valve was changed from 0.085 square inch to 0.045 square inch after second round.	Fired to sea with changes of elevation and azimuth. Breechblock worked hard toward the end of test. The detachment was very efficient, and only one detachment was used for the thirty shots.	80 seconds were lost, due to sticking of primers and breechblock. Temperature of oil in cylinder at beginning 69.5° F.; at end, 106° F. Breech mechanism operated by one revolving crank.	Full service charges of smokeless powder similar to that of preceding series. Service cast-iron shot; weight, 575 pounds. Ammunition was served from a hoist about 66 feet from the piece.	7 29	15
16	9 10 28.7	51.4							7 12	15
17	9 11 20.9	52.2							8 15	15
18	9 12 17.9	57							8 3	15
19	9 13 9.3	51.4							7 52	15
20	9 14 1.5	52.2							6 52	15
		52.2								

21	9	14	53.7								7	8	15
22	9	15	50.7	57							8	0	15
23	9	16	49.5	58.8							8	20	15
24	9	18	8.5	79	20 s. lost						8	0	15
25	9	19	7.3	58.8							....	....	15
26	9	19	57.5	50.2							7	40	15
27	9	21	7.3	69.8	20 s. lost						6	50	15
28	9	22	2.7	55.4							....	....	15
29	9	22	58.9	56.2							7	52	17
30	9	23	50.1	51.2							7	42	17
31	9	24	53.3	63.2							....	....	18
32	9	25	40.3	47	Last shot of series for rapidity.						8	15	18
33	9	34	28	....	....	....					12	20	17

a See column "Special remarks." Omitting the three intervals where time was lost, the average becomes 53.2 seconds.

TABLE VII.—*Record of firing at Fort H. G. Wright, July 29, 1902, to test the disappearing carriage for 10-inch B. L. rifle.*

[Carriage No. 54, model 1898.]

No. of fire.	Time of firing.	Interval between shots of series.	Total time between first and last shot of series.	Average interval between shots of series.	Remarks on carriage.	General remarks.	Special remarks.	Ammunition.	Quadrant elevation. Before firing.	Quadrant elevation. After firing.	Recoil in notches
	h. m. s.	m. s.	m. s.	m. s.					° ′	° ′	
1	2 14 42	....	....	....	Carriage worked well, but it was thought advisable to close the throttle valve.				6 0	5 38	21
2	2 18 10	....	....	....					6 0	5 40	17
3	2 20 8	First of series of 10 for rapidity.							6 0	....	21
4	2 21 48.2	1 40.2							7 0	....	21
5	2 23 35.4	1 47.2							7 30	7 18	21
6	2 25 20.8	1 45.4							7 0	7 18	21
7	2 27 1	1 40.2							6 45	6 20	21
8	2 28 40	1 39	14 45.6	1 38.3		Fired to sea with change of elevation and azimuth. The mushroom head and pad were inspected after the first series and the pad was found so much deformed that the breech could not be closed. A new pad was put in by the ordnance workmen present and a series of 30 shots for rapidity was begun. It was soon evident that the series could not be completed on account of the failure	Temperature of oil in cylinders at beginning, 89°; at end 12 shots, 114.6°. Breechblock worked hard during the series. Detachment fairly efficient and consisted of 3 noncommissioned officers and 20 privates. Railing of platform was so close to gun that it interfered materially with the loading. Ammunition was served from hoist about 66 feet from piece. Breechblock worked		7 00	6 42	21
9	2 30 20.4	1 40.4							8 0	7 49	21
10	2 31 48.4	1 28							7 45	7 31	21
11	2 33 18.6	1 30.2							8 30	8 18	20
12	2 34 53.6	1 35 Last of first series.						Full service charge of smokeless powder, Du Pont, lot 1, 1900; weight, 153 pounds; P., 36,000; I. V., 2,300; granulation, 32. Service cast-iron shot; weight, 575 pounds.	9 0	8 51	19
13	3 11 34	First of series of 30 for rapidity.							8 0	7 43	14
14	3 13 2.4	1 28.4							7 0	6 35	14
15	3 15 24.4	2 22	a1 12		Carriage worked perfectly.				7 15	7 7	15
16	3 17 16.4	1 52							7 45	7 30	14
17	3 18 58.8	1 42.4							8 0	7 40	15
18	3 20 27.6	1 28.8							7 30	7 10	15
		1 25.5									

19	3 21 53.1	Series not completed 1 28.5			of the breech mechanism; the latter could not be closed after sixteenth round.	hard during the first series. Breechblock operated by one revolving crank.	7 10	6 50	16
20	3 23 21.6	.... 2 6.4					6 50	6 54	19
21	3 25 28	.... 1 29					7 15	7 48	18
22	3 26 57	.... 1 27.8					8 0	7 58	19
23	3 28 24.8	Almost impossible to remove breechblock. 2 49					7 5	6 45	17
24	3 31 13.8	.... 3 25.6					....	10 47	17
25	3 34 39.4	.... 2 7.6					8 0	7 36	15
26	3 36 47	.... 2 49.6					6 50	6 23	16
27	3 39 36.6	.... 3 27.2					7 0	6 36	16
28	3 43 3.8	....					7 0	6 33	16

Series stopped.

[a] This time to be deducted here, due to sticking of breechblock.

TABLE VIII.—*Record of firing at Sandy Hook Proving Ground July 28, 1902, to test nondisappearing carriage for 10-inch B. L. rifle.*

[Carriage No. 6, model 1898.]

No. of fire.	Time of firing.	Interval between shots of series.	Total time between first and last shot of series.	Average interval between shots of series.	Remarks on carriage.	General remarks.	Special remarks.	Ammunition.	Quadrant elevation.	Recoil.
	h. m. s.	*m. s.*	*m. s.*	*m. s.*					° ′	*Ins.*
1	10 23 6	....	....	....	Stopped 15/16 inch short of firing position.	Fired all shots to sea, constantly changing the elevation or azimuth or both. Breechblock operated by two revolving cranks.	Temperature of oil in cylinder at beginning of test was 92.8°; temperature at end 109°. The projectiles were served from platform about 14 feet from piece; the powder was served from behind a traverse about 70 feet from piece and 12 feet lower. The detachment serving the piece was fairly efficient and consisted of 3 noncommissioned officers and 15 privates.	Full service charge of smokeless powder, Du Pont, lot 1, 1900; I. V., 2,250; P., 34,460; nitrocellulose; granulation, 32; weight charge, 145 pounds. Service cast-iron shot; weight, 575 pounds.	9 0	44
2	10 26 12	....	....	....	Stopped 7/16 inch short of firing position.				9 0	45.5
3	10 30 42	First shot first series for rapidity.			Stopped 3/8 inch short of firing position.				9 0	45
4	10 32 26.4	1 44.4	1 44.4	....	.....do..........				9 0	45
5	10 33 59.2	1 32.8			.....do..........				9 0	45
6	10 35 24.6	1 25.4			.....do..........				10 0	45
7	10 37 12.1	1 47.5			Stopped 7/8 inch short of firing position.				9 30	45
8	10 38 58.3	1 46.2	16 5.7	1 47.3	Stopped 1/8 inch short of firing position.				9 15	45
9	10 40 57.5	1 59.2			.....do..........				9 45	45
10	10 43 24.5	2 27			.....do..........				10 15	45
11	10 45 9.5	1 45			Stopped 1 inch short of firing position.				9 35	45.5
12	10 46 47.7	1 38.2			Stopped 3/4 inch short of firing position.				10 30	45

TABLE IX.—*Record of firing of a series of 30 shots for rapidity under service conditions at Sandy Hook Proving Ground to test barbette carriage for 10-inch B. L. rifle.*

[Carriage No. 6, model 1893.]

No. of fire.	Time of firing.	Interval between shots of series.	Total time between first and last shot.	Average interval between shots.	Remarks on carriage.	General remarks.	Special remarks.	Ammunition.	Quadrant elevation.	Recoil.
	h. m. s.	*m. s.*	*m. s.*	*m. s.*					° ′	*Ins.*
1	11 36 53	2 16.6	46 28	1 36.13	Worked perfectly	All the shots were fired to sea, the elevation and azimuth being constantly changed. The carriage was one which is used for testing purposes, and the constant changing of throttling-bar bolts no doubt affected the leakage mentioned in preceding column.	The breechblock jammed when loading for the first shot, and a new latch had to be put on. The block worked slightly hard during the first 15 shots and quite hard during the last 15. Temperature at beginning 109° and at end 136°. Three detachments served the piece. The first was a good one. The second served shots 11-19 and was largely made up of recruits. The third detachment was a very efficient one and served the last 10 shots (21-30) in 10 minutes 59.2 seconds (9 intervals). Each detachment consisted of 3 noncommissioned officers and 15 privates.	Full service charge of smokeless powder; Du Pont, lot 1, 1900; I. V., 2,250; P., 34,460; nitrocellulose; granulation, 32; weight, 145 pounds. Service cast-iron shot; weight, 575 pounds.	9 0	46
2	11 39 9.6	1 42.8			Stopped ¾ inch short of firing position.				9 45	45.75
3	11 40 52.4	1 33			Worked perfectly				10 15	46
4	11 42 25.4	1 49			do				9 15	46
5	11 44 14.4	1 20			Oil began to leak through throttling-bar bolts and leakage continually increased until end of firing.				10 30	46
6	11 45 40.4	1 27							9 35	46
7	11 47 7.4	1 37							10 45	46
8	11 48 44.4	1 26							9 15	46.25
9	11 50 10.4	1 25.8							10 40	46
10	11 51 32.6	2 16.2							10 30	46.25
11	11 53 52.4	2 11.4							10 30	46
12	11 56 3.8	2 4.2							10 0	46
13	11 58 8	1 44.8							9 45	46.25
14	11 59 52.8	1 36.8							10 15	46.25
15	12 1 29.6	1 41.8			Stopped 1¼ inches from firing position.				10 40	46
16	12 3 11.4	1 49.8							9 15	46
17	12 5 1.2	1 40.2							10 25	46.5
18	12 6 41.4	2 4							9 30	46.5

TABLE IX.—*Record of firing of a series of 30 shots for rapidity under service conditions at Sandy Hook Proving Ground to test barbette carriage for 10-inch B. L. rifle*—Continued.

[Carriage No. 6, model 1893.]

No. of fire.	Time of firing.	Interval between shots of series.	Total time between first and last shot.	Average interval between shots.	Remarks on carriage.	General remarks.	Special remarks.	Ammunition.	Quadrant elevation.	Recoil.
	h. m. s.	*m. s.*	*m. s.*	*m. s.*					° ′	*Ins.*
19	12 8 45.4	....	10 59.2	1 13.32	....	All the shots were fired to sea, the elevation and azimuth being constantly changed. The carriage was one which is used for testing purposes, and the constant changing of throttling-bar bolts no doubt affected the leakage mentioned in preceding column.	The breechblock jammed when loading for the first shot, and a new latch had to be put on. The block worked slightly hard during the first 15 shots and quite hard during the last 15. Temperature at beginning 109° and at end 136°. Three detachments served the piece. The first was a good one. The second served shots 11-19 and was largely made up of recruits. The third detachment was a very efficient one and served the last 10 shots (21-30) in 10 minutes 59.2 seconds (9 intervals). Each detachment consisted of 3 noncommissioned officers and 15 privates.	Full service charge of smokeless powder; Du Pont, lot 1, 1900; I. V., 2,250; P., 34,460; nitrocellulose; granulation, 32; weight, 145 pounds. Service cast-iron shot; weight, 575 pounds.	9 15	46.5
20	12 10 49	2 3.6			....				9 45	46.5
21	12 22 21.8	1 32.8			Stopped ½ inch from firing position.				9 35	46
22	12 13 59.8	1 38			Stopped 1 inch from firing position.				9 15	46.5
23	12 15 15.4	1 15.6							9 30	46.5
24	12 16 28.8	1 13.4			....				9 0	47
25	12 17 41	1 12.2			....				10 0	47
26	12 18 47.4	1 6.4			....				9 30	47
27	12 19 58.2	1 10.8			....				9 35	47
28	12 21 3	1 4.8			....				9 20	46.5
29	12 22 9.6	1 6.6			....				9 0	47
30	12 23 21	1 11.4			....				9 40	47

TABLE X.—*Record of firing at Fort H. G. Wright July 30, 1902, to test the disappearing carriage for the 12-inch B. L. rifle.*

[Carriages Nos. 22 and 21, model 1897.]

No. of fire.	Time of firing.	Interval between shots of series.	Total time between first and last shot of series.	Average interval between shots of series.	Remarks on carriage.	General remarks.	Special remarks.	Ammunition.	Quadrant elevation before firing.	Recoil in notches.
	h. m. s.	m. s.	m. s.	m. s.					° ′	
1	10 26 48.5	....	....	....	Carriage No. 22. Throttling pipe burst. (See fig. 1.)	Fired to sea with changes in elevation and azimuth. The breechblock was working hard during the firing and jammed badly in closing it after the last shot.	Temperature of oil in cylinder before first shot, 78°. Ammunition was served from hoist about 84 feet from piece. The detachment serving the piece was excellent, and consisted of 3 noncommissioned officers and 25 privates.	Full service charge of smokeless powder, lot 1, 1900, Du Pont; I.V., 2,250; P., 34,500; gran., 26¼; series 26; weight, 245 pounds; nitrocellulose. Service cast-iron shot; weight, 1,000 pounds.	6 15	22
1	10 58 45	....	....	....	Carriage No. 21. Worked perfectly.				6 15	24
2	11 7 31	....			....do........				6 30	26
3	11 8 51	1 20	2 36	1 18	....do........				6 45	28
4	11 10 7	1 16			Throttling pipe burst. (See fig. 1.) Series stopped.				....	26

TABLE XI.—*Record of firing at Fort H. G. Wright August 12, 1902, to test the disappearing carriage for 12-inch B. L. rifle.*

[Carriage No. 21, model 1897.]

No. of fire.	Time of firing.	Interval between shots of series.	Interval between first and last shot of series.	Average interval between shots of series.	Remarks on action of carriage.	General remarks.	Special remarks.	Ammunition.	Quadrant elevation.	Recoil in notches.
	h. m. s.	s.	m. s.	s.					° ′	
1	10 0 15	....	....	....	Worked perfectly..	Fired to sea with change in elevation and azimuth. The gas-check pad was in bad shape at end of firing and retarded last few shots. Breechblock worked very hard during last three shots. Lost 36 seconds, due to sticking of gas-check pad. The carriage was put in order just before the test.	3 gallons of oil were removed from the cylinders. Temperature of oil in cylinders at beginning, 69.5°. at end, 96.5°. Detachment was excellent, consisting of 3 noncommissioned officers and 26 privates (including 1 extra man for priming and 1 for assisting on breech).	Full service charge of smokeless powder, lot 1, 1900, Du Pont; I. V., 2,250; P., 34,500; gran., 264; weight, 245 pounds; nitrocellulose. Service cast-iron shot; weight, 1,000 pounds; served from hoist about 84 feet away from piece.	6 0	27
2	10 11 30	....	....	....	.....do				6 30	29
3	10 14 15	First of series for rapidity			.....do				7 0	29
4	10 15 11	56			.....do				7 30	29
5	10 16 8	57			.....do				8 0	29
6	10 17 9.6	61.6			.....do				7 30	29
7	10 18 6.2	56.6	9 18.6	58.1	.....do				7 0	29
8	10 19 5.2	59			.....do				6 30	28
9	10 20 2.2	56.8			.....do				6 0	30
10	10 21 4.2	62.2	Lost 7		.....do				6 30	29
11	10 22 79.2	75	Lost 15		.....do				7 0	30
12	10 24 33.6	74.4	Lost 14		.....do				7 30	29
		Last of series for rapidity								
13	10 42 18	....	....	....	.....do				9 57	29

TABLE XII.—*Record of firing at Fort Du Pont, Del., July 25, 1902, to test the nondisappearing carriage for 12-inch B. L. rifle.*

[Carriage No. 21, model 1892.]

No. of fire.	Time of firing.	Interval between shots of series.	Total time between first and last shot of series.	Average interval between shots of series.	Remarks on carriage.	General remarks.	Special remarks.	Ammunition.	Quadrant elevation.	Recoil in inches.
	h. m. s.	m. s.	m. s.	m. s.					° ′	
1	1 25 53	....	....	....					5 0	46⅛
2	1 34 38	First of series for rapidity....							5 5	46⅛
3	1 39 36	4 58							6 30	46¼
4	1 43 15	3 39							7 0	46¼
5	1 46 42	3 27							6 0	46¼
6	1 50 22	3 40	31 49	a3 24.1	Carriage worked perfectly, except slight leakage at left cylinder filling plug and front end right cylinder.	Fired in direction of fixed target with varying elevations.	The projectiles were served from a hoist about 30 feet from the piece, and the powder by hand up the emplacement steps; the magazine about 25 feet lower than the loading platform and 80 feet from the piece. The detachment was generally inefficient and consisted of 3 noncommissioned officers and 24 privates. The carriage was inspected and put in order by an expert one month before the test.	Full service charge smokeless powder, 245 pounds, lot 1, 1900; serial No. 28; I. V., 2,250; P., 34,500; gran., 26¼; nitrocellulose. Service cast-iron shot; weight, 1,000 pounds.	5 55	46¼
7	1 53 41	3 19							5 55	46⅛
8	1 56 58	3 17							5 48	46⅜
9	2 0 23	3 25							5 30	46⅛
10	2 3 21	2 58							5 10	46⅜
11	2 6 27	3 6 Last of series for rapidity							5 10	46⅛
12	2 13 43	....	....	....	....	Sanded rails and piston rods.			5 14	46¼

a 72 seconds of time were lost due to sticking of primer and delay due to shipping, leaving 30 minutes 37 seconds as the corrected elapsed time, from which 3 minutes 24.1 seconds is obtained.

TABLE XIII.—*Variations from true quadrant elevation produced by failure of the carriage to reach its proper position when tripped.*

[All variations were depressions.]

Distant from firing position.	Elevation. 0		Elevation. 3		Elevation. 5	Distant from firing position.	Elevation. 0	Elevation. 3	Elevation. 5
	′	″	′	″	′		′	′	′
¼ inch		20		40	8½	6 inches	11	17	22
½ inch	1	0	1	0	4	7 inches	12	19	25
¾ inch	1½	0	1½	0	5½	8 inches	10	22	25
1 inch	2	0	2½	0	6½	9 inches	8	23	30
2 inches	6	0	8½	0	7	10 inches	6	23	28
3 inches	7	0	6	0	15	11 inches	5	22	28
4 inches	8	0	11	0	18	12 inches	3	22	28
5 inches	9½	0	14	0	20				

TABLE XIV.—*Time involved in the various operations of loading.*

[Time is reckoned in each case from command "load," or instant of previous discharge.]

6-INCH B. L. RIFLE ON DISAPPEARING CARRIAGE.

Operations.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″
Breech opened	1.5	×	2	2	2	×	2	2	2	2	2	....	....	....	....
Shot home	14	×	8	7	6	10	10	8.5	11	9.5	9	....	....	....	....
Breech closed	18	×	17	10	10	15	14	10.5	14	10.5	10	....	....	....	....
Tripped	19	×	20	11	11	16	15	10.5	15	11.5	12	....	....	....	....
Fired	25	×	28.5	16	45	21	20.8	17.5	20	19	17.2	....	....	....	....

8-INCH B. L. RIFLE ON DISAPPEARING CARRIAGE.

Breech opened	×	×	×	28	×	×	×	×	15	18	21	27	....	....	....
Shot home	×	×	×	37	35	85	34	47	30	28	29	×	....	....	....
Breech closed	×	×	48	54	×	×	44	×	47	44	38	48	....	....	....
Tripped	×	×	×	×	×	×	×	×	×	×	×	×	....	....	....
Fired	×	×	×	105	105	90	82	118	70	120	80	75	....	....	....

8-INCH B. L. RIFLE ON NONDISAPPEARING CARRIAGE.

Breech opened	×	×	×	×	×	×	×	×	×	23	22	....	....	....	....
Shot home	×	×	×	×	42	×	×	30	30	45	52	....	....	....	....
Breech closed	×	×	60	×	×	×	×	52	×	×	×	....	....	....	....
Fired	×	×	×	97	99	100	92	102	69	79	73	....	....	....	....

10-INCH B. L. RIFLE ON DISAPPEARING CARRIAGE.

Breech opened	×	5.8	×	10	9	10	8	7	6	7	5	×	6	6	8
Shot home	16	20.8	×	22	22	20	20	17	21	21	18	18	19	16	20
Breech closed	30.4	41.8	×	43.8	38.5	36	37	42	×	×	34	40	48.5	36	41
Tripped	×	×	×	49	46	46.5	42	45	×	57	38	41	55	40	44
Fired	×	×	×	57	56.4	58.5	49.2	57.2	×	×	47.2	49.5	63	47.2	60.2

10-INCH B. L. RIFLE ON NONDISAPPEARING CARRIAGE.

Breech opened	×	23	×	×	×	×	×	×	×	×	×	×	×	×	×
Shot home	×	43	58	61	60	×	46	56	51	×	68	67	73	55	47
Breech closed	×	76	79	×	85	×	71	89	76	×	×	114	104	88	77
Fired	×	136.6	102.8	93	109	86	87	97	86	85.8	136.2	131.4	124.2	94.8	96.8

TABLE XIV.—*Time involved in the various operations of loading*—Continued.

[Time is reckoned in each case from command "load," or instant of previous discharge.]

10-INCH B. L. RIFLE ON DISAPPEARING CARRIAGE.

Operations.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
Breech opened	11	9.5	10	7	9.5	8	9	11	7.2	6	6	6	6.5	10	8
Shot home	29	20.4	25	18.8	×	20	20.5	23	28	26	22	30	20	24.8	23
Breech closed	41	38	45	37	41.2	39	44	49	×	51	39	×	43	45	40
Tripped	45	44	49	45	45	44	49	.....	×	×	42	×	47	48	40
Fired	51.4	52.2	57	51.4	52.2	52.2	57	58.8	×	58.8	50.2	×	55.4	56.2	63.2

10-INCH B. L. RIFLE ON NONDISAPPEARING CARRIAGE.

Breech opened	×	×	×	25	×	×	16	17	×	×	×	×	×	×	×
Shot home	×	72	58	73	56	60	45	48	×	45	×	×	×	32	37
Breech closed	82	98	×	105	100	×	82	69	×	69	×	63	×	58	62
Fired	101.8	109.8	100.2	124	123.6	92.8	98	75.6	73.4	72.2	66.4	70.8	64.8	66.6	71.4

12-INCH B. L. RIFLE ON DISAPPEARING CARRIAGE.

Operations.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
Breech opened	7.6	6.8	×	9.5	9.5	12	12	11	×	11	10	13	....	....	....
Shot home	20.2	20	×	22	22	26	22	22	21	21	23	26	....	....	....
Powder in	36	37	×	37	37	42	35	37	35	35	38	40	....	....	....
Breech closed	42.5	46	×	46	47	52	47	50	48	×	×	×	....	....	....
Tripped	44	47	×	47	48.6	53	48	51	49	×	×	×	....	....	....
Fired	×	×	×	56	57	61.6	56.6	59	56.8	×	×	×	....	....	....

12-INCH B. L. RIFLE ON NONDISAPPEARING CARRIAGE.

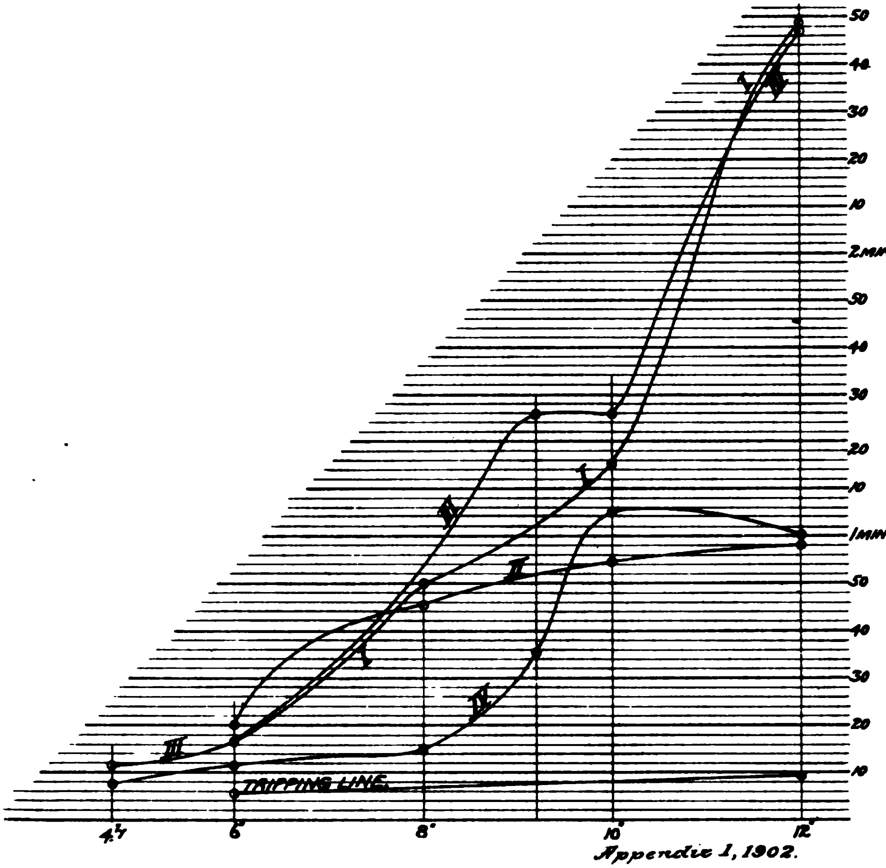
Breech opened	×	×	×	×	×	×	×	×	×	×	×	....	....	....	....
Shot home	×	×	80	×	81	142	84	107	88	85	×	....	....	....	....
Powder in	×	×	105	×	106	162	106	×	110	110	×	....	....	....	....
Breech closed	×	×	118	125	115	129	124	×	130	140	×	....	....	....	....
Fired	×	×	215	219	207	220	199	197	205	178	185	....	....	....	....

NOTE.—Intervals marked × are defective, due to not observing or to necessity for taking out time.

The curves of Plate I show graphically the great increase in the rapidity of fire obtained by improving the mounts and facilities of loading. It is to be noted that the loading operations were all manual for the firing with the United States guns and that the ammunition was supplied from magazines. The curves also show that the tripping interval, while small as compared to the time for a round with a heavy gun, is so large as compared with the time for a round with a small caliber piece that it must materially reduce the rapidity of fire for smaller calibers.

The curves of Plate II show the loss of time in handling the ammunition for the present United States nondisappearing carriage, emphasize the necessity for better loading facilities, and indicate in what operations improvements may readily be made. The very slight differences in the curves for the 10 and 12 inch gun carriages are especially worthy of remark.

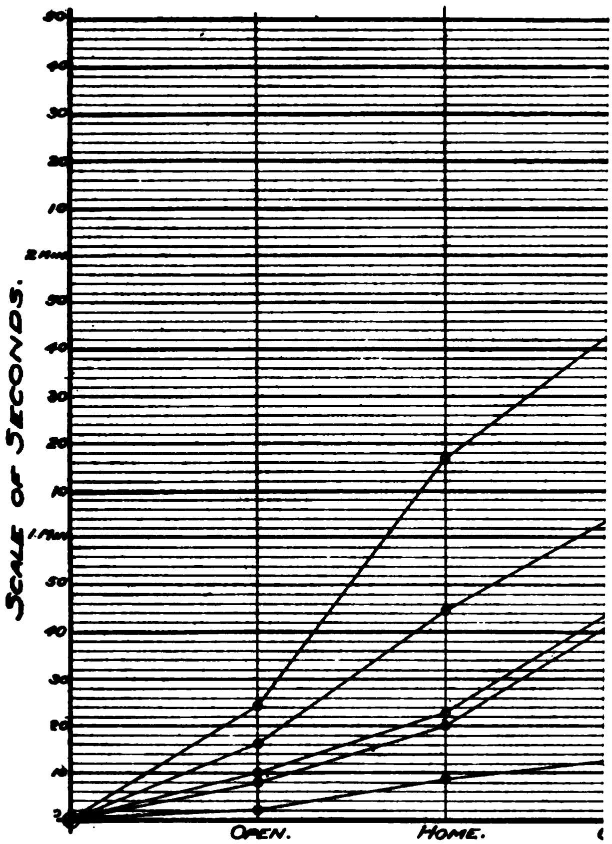
Plate I.



FIRING CURVES FOR VARIOUS CALIBRES UP TO 12 INS. SHOWING THE EFFECTS OF MOUNTS UPON THE RAPIDITY OF FIRE.

CALIBRE IS LAID OFF ON THE HORIZONTAL AXIS AND AVERAGE INTERVAL BETWEEN ROUNDS ON THE VERTICAL AXIS.

I IS FOR U.S.N.D.C. II U.S.D.C. III ENGLISH SHIP MOUNTS (OLD MODELS) IV ENGLISH SHIP MOUNTS (NEW MODELS) FASTEST RATE PRIZE FIRING. THE POINT ON U.S. CURVES FOR 8 INCH IS OBTAINED BY COMPARISON OF THE RESULTS OF TEST FIRING WITH FIRING AT SANDY HOOK PROVING GROUND.



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HEAVY CALIBRE GUNS ARE ESPEC
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AND 10^{IN} N.D.C.-12^{IN} N.D.C.

FIG. 1.—PIECES OF THE THROTTLING PIPES WHICH BURST ON THE DISAPPEARING CARRIAGES FOR 12-INCH B. L. RIFLE.

Appendix I, 1902.

FIG. 2.—LOADING A GUN MOUNTED ON A NONDISAPPEARING CARRIAGE, SHOWING EXPOSURE OF ALL THE MEN EXCEPT THOSE ON THE CRANKS.

Appendix I, 1902.

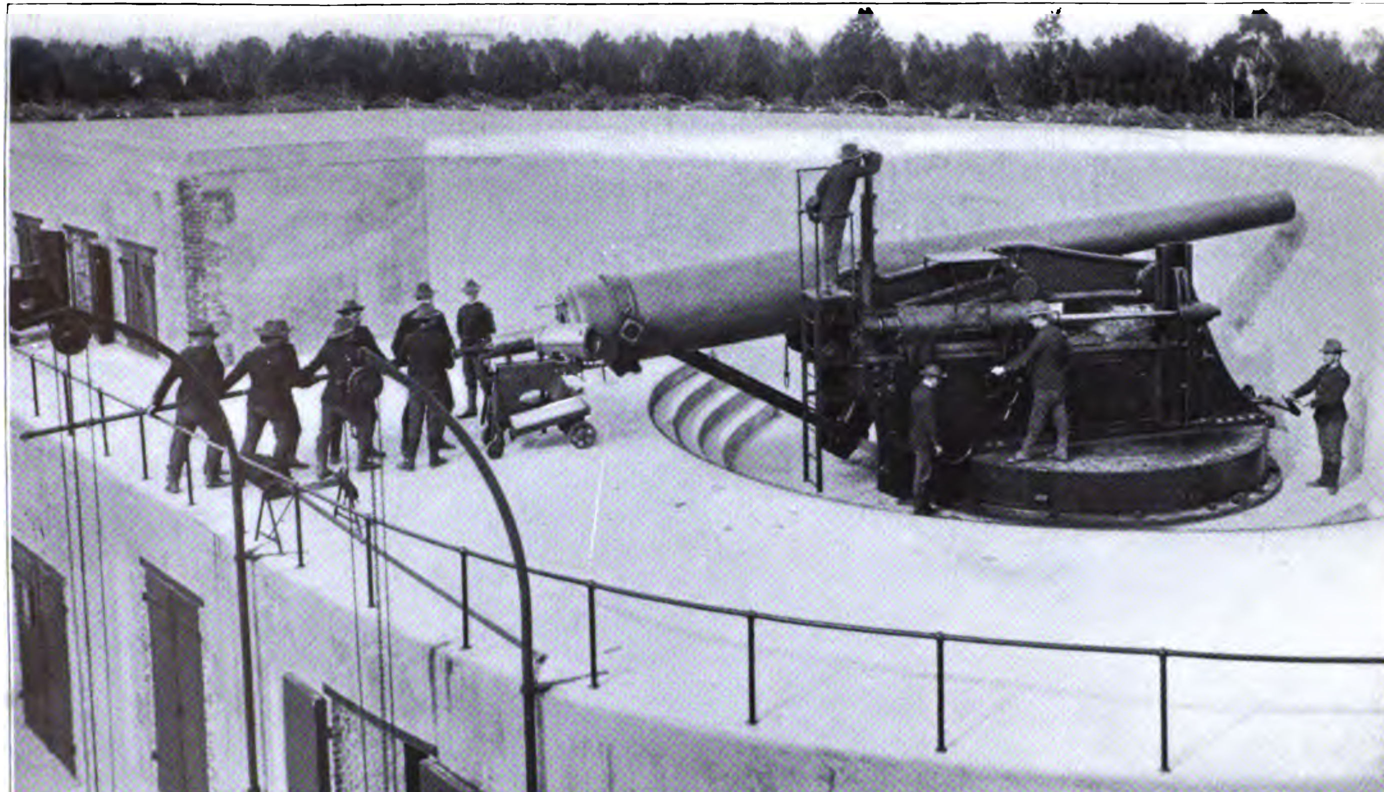


FIG. 3.—LOADING A GUN MOUNTED ON A DISAPPEARING CARRIAGE, SHOWING ALL THE MEN PROTECTED EXCEPT THE GUNNER WHEN DIRECT AIMING IS EMPLOYED.

With indirect laying the gunner would not be on his platform.

Appendix I, 1902.

FIG. 4.—THIS SHOWS THE PROTECTION GIVEN BY THE SHIELD ON THE PEDESTAL MOUNT FOR 6-INCH B. L. RIFLE TO THE GUNNER AND LOADING DETACHMENT.

Compare with fig. 5, which is for the same gun, looking from the rear.

Appendix I, 1902.

FIG. 5.—REAR VIEW, SHOWING A DETACHMENT LOADING THE 6-INCH B. L. RIFLE ON THE ARMSTRONG PEDESTAL MOUNT.

Compare with fig. 4.

FIG. 6.—LOADING A 6-INCH B. L. RIFLE MOUNTED ON A DISAPPEARING CARRIAGE, SHOWING THE EXPOSURE OF THE GUNNER.

The photograph was taken just after the piece had disappeared after being fired.

Appendix I, 1902.

FIG. 7 —LOADING A GUN MOUNTED ON A NONDISAPPEARING CARRIAGE, SHOWING THE EXPOSURE OF THE GUN, CARRIAGE, AND BREECH MECHANISM.

Compare with figs. 3 and 8.

Appendix I, 1902.

FIG. 8.—THIS SHOWS A GUN MOUNTED ON A DISAPPEARING CARRIAGE AT THE INSTANT JUST BEFORE FIRING.

The exposure seen here is only for a few seconds. Compare with figs. 7 and 9.

FIG. 9.—THIS SHOWS A GUN MOUNTED ON A DISAPPEARING CARRIAGE JUST AFTER FIRING WITH SMOKELESS POWDER.

The cloud is dust from the parapet slope.

Appendix I, 1902.

FIG. 10.—THE LINE MARKED 3° 15′ IS THE LINE OF COVER FOR A MAN JUST IN REAR OF THE PIECE.

The plane of cover through this line would pass above the head of the noncommissioned officer to the right. The position of the piece for which this line is drawn is the most unfavorable one for cover of the detachment.

Appendix I, 1902.

APPENDIX II.

REPORT OF THE COMMANDING OFFICER OF WATERTOWN ARSENAL UPON THE TEST OF GUN STEEL CONTAINING STREAKS.

WATERTOWN, MASS., *November 11, 1902.*

SIR: In compliance with your instructions of the 1st instant (4044), I have the honor to submit herewith a brief report on the subject of "streaks" such as have appeared in gun forgings.

The tests made at this arsenal have been mainly confined to three hoops of gun material reduced in thickness to bring them within the capacity of our apparatus for applying bursting strains by hydrostatic pressure. Only a limited number of small specimens with streaks have been tested here.

I have not been able to learn of the nature and extent of the tests and experiments that have preceded the submission of the hoops for test at this arsenal, but it has been more than once suggested that these hoop tests might very well have been preceded by the test of a large number of small specimens cut from hoops tangentially or normal to the direction of the streaks. Test specimens thus located would necessarily be very small; but if the streaks are as liable to occur in slab forgings as in tubular forgings, the size of the test specimens, either perpendicular to or in the direction of the streaks, breadth and thickness could be obtained for that amplification of tests usually so desirable in investigations of this nature.

The following description and remarks are compiled from the records of the testing department. I am not prepared to express any opinion or to advance any theories upon the subject:

STREAKS IN GUN FORGINGS.

The term "streak" has been applied to the local appearance of gun forgings in process of machining, referring to differences in color or the lack of continuity of the metal as commonly witnessed in more or less well-defined lines or paths which are found to follow a direction parallel to the axes of the forgings. According to their color they are designated as light streaks or dark streaks, and they may be present separately or associated in the same forging. They are not found evenly distributed, being more numerous in some zones than in others, and frequently present in groups in the general localities where they occur. Their dimensions range from the fraction of an inch to upward of 4 feet in length, penetrating at times one-half inch or more below the surface. In terms of their other dimensions they are comparatively narrow in width.

Their presence is made manifest when the metal is machined, and greater or less prominence may be given their development by varying the conditions pertaining to the machine tool in respect to the depth of cut and feed employed. Streaks are not introduced by the operation of machining, but their presence is thus made known. Different etching solutions will aid in bringing the streaks clearly into view. Etching is not essential for this purpose in a microscopic sense, but assists ordinary vision in discerning a streaked state.

Direct experiments in the forge shop upon unstreaked steel have not resulted in the production of streaks of the type under consideration. A careful examination of streaked metal frequently shows the presence of short, interrupted dark lines, which are actually seams, places in which the continuity of the metal is wanting.

The association of seams with streaks leads to the inference that they may have a common origin, and apparently the time of their formation is restricted to the period when the metal is in the ingot. The origin of these streaks and seams and the causes which lead to their formation are, however, controversial questions.

The shapes of ingot cavities, when such exist, are changed by the subsequent operation of forging. The walls may be brought into contact, a partial or complete welding effected, and the junction of such parts extended materially beyond their original lengths as the forging is drawn out under the hammer. The tensile properties under stresses applied parallel to the direction of such extended junctions are not generally modified thereby, but loads applied normal to them may be expected to show deficiency in ultimate strength and elongation. These remarks are based upon the behavior of certain streaked forgings subjected to tangential stresses; that is, normal to the general direction of the streaks.

Shop experience has shown that streaks may be changed in appearance somewhat at will. A file finish obscures them. A medium lathe cut brings them into prominence, while a heavy roughing chip tears the metal so generally that planes of weakness along the seams can not be specifically recognized. So intimate may be the contact of the metal on either side of a seam that the mild effect of removing a small amount of surface metal with the file does not enlarge the joint and may obscure the junction in the same manner as the finish over a countersunk rivet obscures a mechanical fit. In the more severe operation of turning off a lathe chip the shearing plane is deflected when lines of less resistance are met, and the visual result is a streak. The mere fact that a chip will carry across a streak should not be accepted as evidence that the physical properties are unimpaired by the presence of the streak.

So far as known, the presence of streaks is attended with loss in tensile strength and elongation. Their magnitude, whether singly or in groups, and whether they are lines or welded or nearly welded metal or actual seams will have a bearing on the gravity of the defect, as well as the relative proportions and the positions of the plain and streaked metal in the finished forging.

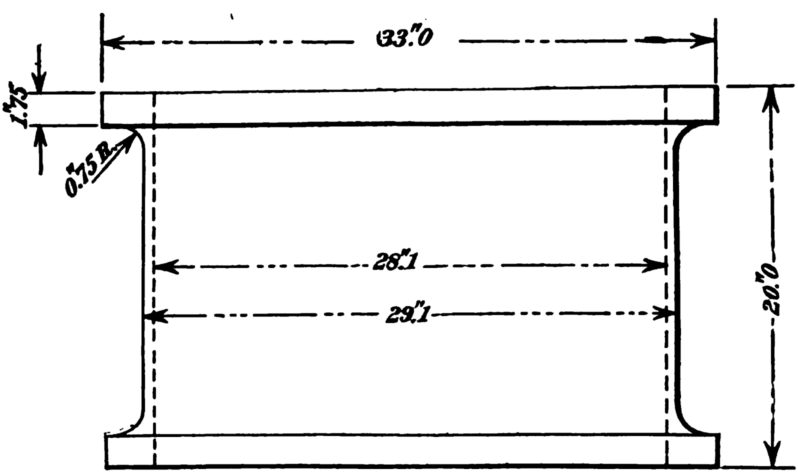
Some bursting tests have been made on hoops of diminished thickness of walls by means of interior hydrostatic pressures and may be described as follows:

Two hoops were prepared, one of which contained streaks and one in which none were visible.

Specimen tests showed the metal to have the following tensile properties:

	Elastic limit.	Tensile strength.	Elongation.	Contraction.
STREAKED HOOP.				
	Lbs. per sq. in.	*Lbs. per sq. in.*	*Per cent.*	*Per cent.*
Mean results	55,500	106,600	17.1	42.7
Maximum	57,000	108,800	19.2	47.1
Minimum	54,000	102,400	15.0	38.3
UNSTREAKED HOOP.				
Mean results	57,000	111,800	12.8	36.0
Maximum	58,000	113,600	13.7	36.9
Minimum	56,000	110,000	12.0	35.2

The hoops were finished for testing in the shapes and dimensions here given:



The walls at the central part of each hoop for a length of 13 inches were one-half inch thick. Flanges were left on the ends to reenforce the strength of the hoop over the hydraulic packings.

The testing was done with a fixture consisting of a body, flanged at the lower end, over which the hoop was placed, and surmounted by a cap bolted to the body. An annular space, 0.75 inch wide on a side, existed between the interior surface of the hoop and the exterior surface of the body, which space contained the hydraulic packings. The end thrust of the packings was resisted by the flanges at the bottom of the body in one direction and by the cap in the other. Communication was established between the annular space and the testing machine through hydraulic piping, and the straining of the hoop effected by admitting oil or water under gradually increasing pressures.

A caliper arm carrying micrometer points was mounted opposite the middle diameter of the hoop under test, and observations taken on the expansions and permanent sets acquired by the application of advancing pressures and their release. At pressures 2,000 and 3,000 pounds

per square inch below the elastic limits of the streaked and unstreaked hoops, respectively, the loads were applied and released 500 times with each hoop. Thereafter the pressures were increased until the limit of rupture was reached.

The ultimate bursting strength of the streaked hoop was reached after one interruption, during which interval a hydraulic packing was renewed. There were several interruptions in the case of the unstreaked hoop, owing to its greater expansion before rupture, when it became necessary to machine the flanges or modify the testing fixture to compensate for the distortion of the test piece.

Each hoop endured the stress 2,000 or 3,000 pounds per square inch below its elastic limit, repeated 500 times, without sensible permanent set in diameter.

In the case of the streaked hoop, its characteristic features became more prominent after passing the elastic limit of the metal and the development of appreciable set. Three short seams were opened perceptibly after a load of 62,000 pounds per square inch tangential fiber stress. At 66,000 pounds per square inch one seam had decidedly gained in prominence, and was then photographed. Rupture finally occurred along the line of this seam. Just before rupture its linear measurements were:

<.65 inch> <.93 inch> <.75 inch> <.80 inch>
<.35 inch> <.30 inch> <.55 inch>

The seam was an interrupted one, consisting of four short seams, as indicated above, between which there were sections of continuous metal. There were other smaller streaks or seams distributed over the exterior and interior surfaces, but those on opposite surfaces were not abreast each other. The seams did not penetrate the walls radially, but dipped obliquely, some in one direction and some in the other.

After fracture it was found that the metal at the principal seam was affected for a distance of 0.15 inch in width, reaching a depth of 0.04 inch below the exterior surface. There were minor streaks not sensibly affected by stresses above the elastic limit, and occasional faint nebulous patches, cluster of minute, irregular-shaped cavities.

The metal of the unstreaked hoop maintained its state of integrity until the time of final rupture. The streaked hoop apparently reached a fiber stress of 93,883 pounds per square inch when a hydraulic packing blew out. Subsequently, rupture occured under a fiber stress of 91,051 pounds per square inch. Owing to the frictional resistance of the rapid current of oil through the piping, it was thought that the registered pressure momentarily reached, corresponding to the higher fiber stress, was not really sustained by the hoop, and the lower value above stated was accepted as properly representing the strength of the metal.

The elastic limit of each hoop under hydrostatic test coincided with the minimum values found in the specimen tests of the metal. In ultimate bursting strength the streaked hoop showed a deficiency in strength over the specimen tests; the unstreaked hoop showed an excess in strength over the specimen tests. The numerical values obtained were as follows:

Hydrostatic tests.

	Hoop.	
	Streaked.	Unstreaked.
Elastic limit ......pounds per square inch..	54,000	56,000
Ultimate strength ......do....	91,051	125,889
Elongation (circumferential) ......per cent..	3.9	18.5

The character of the fractured surface in each hoop was granular, radiating from the incipient point.

The line of fracture in the streaked hoop had its origin at the principal streak on the exterior surface, an interrupted line of alternate seamy and sound metal 4⅛ inches long.

The unstreaked hoop fractured along an element not previously characterized by any unusual local appearance of the metal.

COMPARISONS OF THE RESULTS AND CONCLUSIONS REACHED.

1. The elastic limits of the hoops possessed the values indicated by the specimen tests.

2. Each hoop successfully endured 500 repetitions of a load closely approaching but within the elastic limit of the metal.

3. The presence of streaks exerted a marked influence on the ultimate strength and elongation of the metal.

4. The actual bursting strength of the unstreaked hoop was 34,838 pounds per square inch above that of the streaked one, or, corrected for the difference in the specimen tests of the metal, the above became 27,238 pounds per square inch. Under corrected figures, the strength of the streaked hoop is 77 per cent that of the unstreaked.

5. Compared with their respective tensile specimens, the following values appear:

Streaked hoop, deficiency in strength, 11,349 pounds per square inch.

Unstreaked hoop, excess in strength, 15,889 pounds per square inch.

The streaked hoop has 88.9 per cent the strength of the specimen test.

The unstreaked hoop has 114.1 per cent the strength of the specimen test.

6. The elongation of the streaked hoop was 26.1 per cent that of the specimen test.

The elongation of the unstreaked hoop was 154.1 per cent that of the specimen test.

7. The excess in strength and elongation of the unstreaked hoop over the specimen test is attributed to the reenforcing influence of the flanges of the hoop.

8. The deficiency in strength and elongation of the streaked hoop over the specimen test is attributed to the presence of streaks in the metal.

A supplementary test was made on an additional section of the streaked hoop 9.95 inches long, 28.1 inches interior diameter, 0.50 inch thickness of walls, without flanges.

This section was subjected to interior hydrostatic pressure in the same manner as the primitive test of the hoop.

The elastic limit was found to be 60,000 pounds per square inch tangential fiber stress at the surface of the bore. At a fiber stress of

74,000 pounds per square inch a seam opened perceptibly in a group of streaks.

Pressures were continued until a fiber stress of 90,000 pounds per square inch was reached, at which time it became necessary to renew the hydraulic packings. Two photographs were now taken showing the principal cracks on the exterior and interior surfaces, respectively. These cracks were about 1½ inches apart tangentially, and about the same distance apart in a helical direction at their nearest extremities. Rupture finally occurred along the line of the principal crack on the surface of the bore.

The results of the test were:

Elastic limit	pounds, per square inch..	60,000
Ultimate strength	do....	95,716
Elongation (circumferential)	per cent..	4.1

Appearance of the fractured surface, granular, radiating from two points at the surface of the bore 1.4 inches and 1.6 inches, respectively, from the end of the hoop, and containing a seamy line 6 inches long.

It will be observed that the elastic limit in this test exceeded the minimum specimen values. This feature possesses no further interest, however, than in showing that different parts of a forging may vary in physical properties.

The general result confirmed the primitive test of the streaked hoop and the conclusions drawn therefrom.

Cuts from photographs are appended, showing the appearance of the hoops, streaks, and features at different stages of the tests.

Respectfully,

JOHN G. BUTLER,
Lieutenant-Colonel, Ordnance Department,
U. S. Army, Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

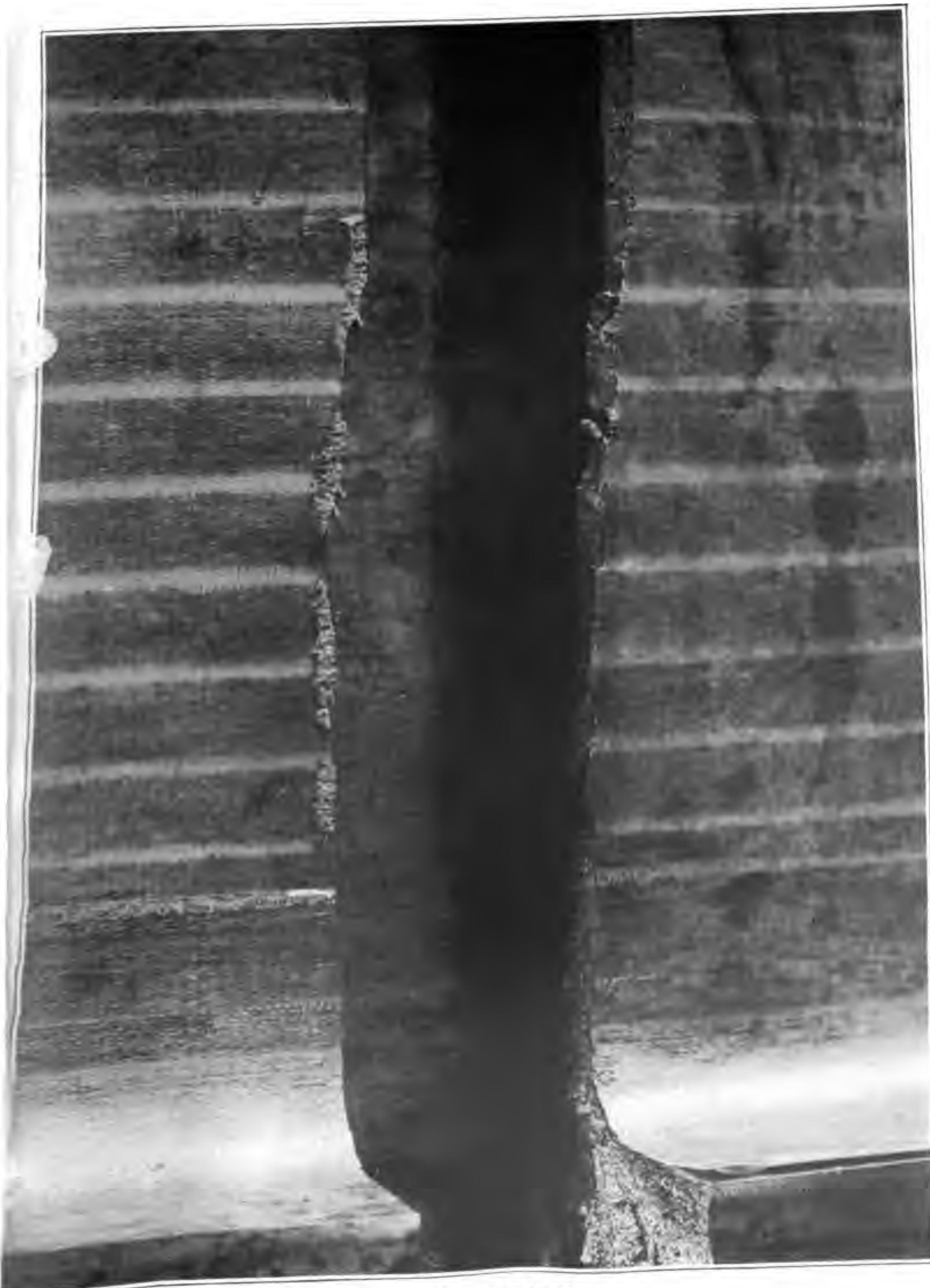
STREAKED HOOP.

Appearance after fracture. Rupture began at streak and extended longitudinally in each direction through the flanges.

Appendix II. 1902.

STREAKED HOOP.

Appearance after fracture. Rupture began at streak and extended longitudinally in each direction through the flanges.



STREAKED HOOP.

Front view of the line of fracture, at the principal streak.

UNSTREAKED HOOP.

Appearance after fracture. Rupture began at a point ."9 from the middle of length of hoop, extending in each direction through the flanges. A secondary fracture started in the upper half, taking an oblique course.

UNSTREAKED HOOP.

General view of fractured surface.

STREAKED AND UNSTREAKED HOOPS AFTI

The u

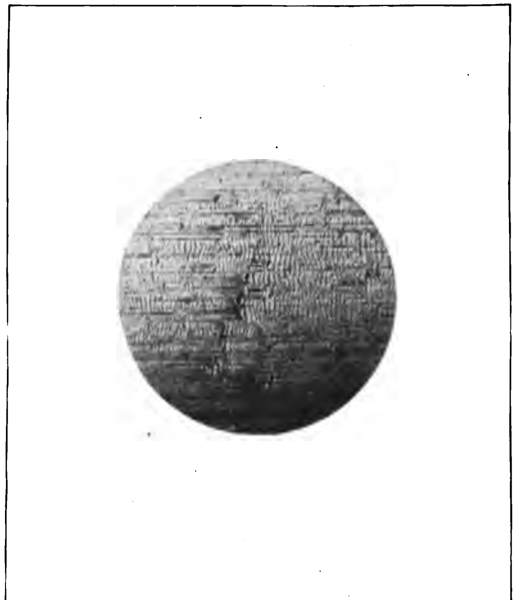
Prominent streak on outside surface.

Prominent streak on inside surface.

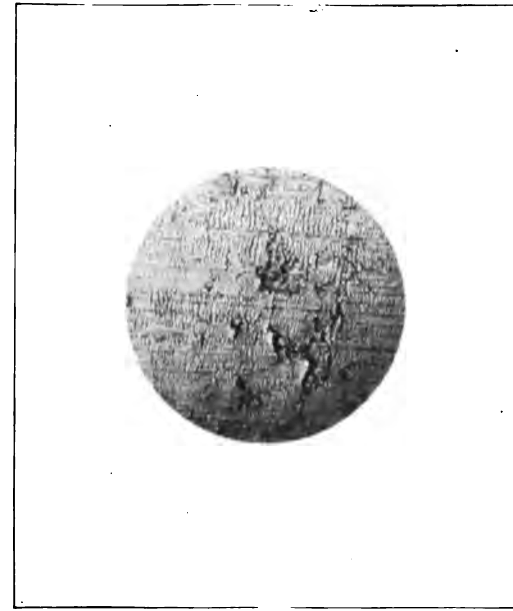
STREAKED HOOP, AFTER FRACTURE.

Magnification, 5 diameters.

PLATE VIII.



Minimum streaked development, exterior surface.



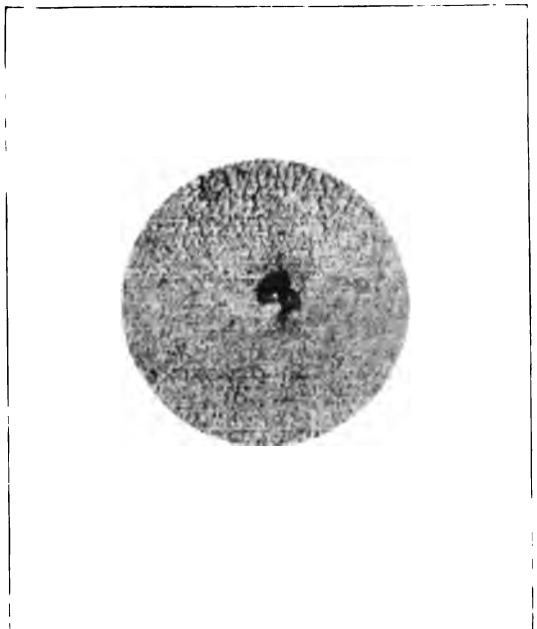
Nebulous development, exterior surface.

STREAKED HOOP, AFTER FRACTURE.

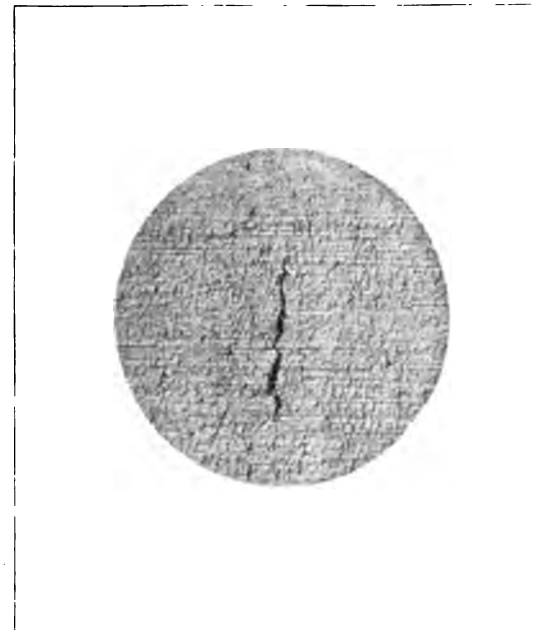
Magnification, 5 diameters.

Appendix II, 1902.

PLATE IX.



Crater-like cavity, interior surface.



Incipient line of fracture, exterior surface.

UNSTREAKED HOOP, AFTER FRACTURE.

Magnification, 5 diameters.

Outside crack.

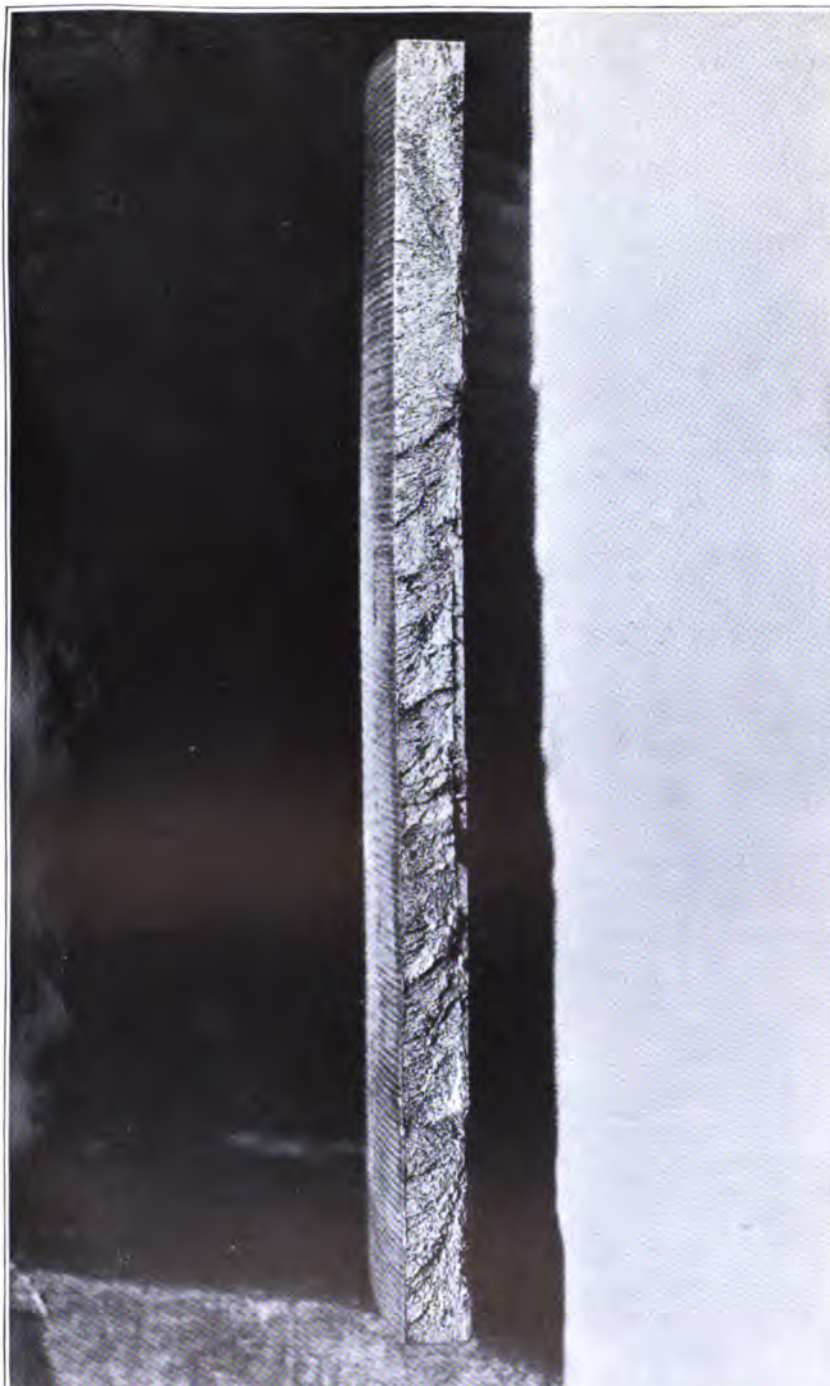
Inside crack.

SUPPLEMENTARY TEST OF STREAKED HOOP.

Photographs of cracks on surfaces of the hoop after a tangential load of 90,000 pounds per square inch on the metal. Natural size.

SUPPLEMENTARY TEST OF STREAKED HOOP.

Appearance after fracture. Ruptured along line of streak on the surface of the bore.



SUPPLEMENTARY TEST OF STREAKED HOOP.

End view of fracture, showing seamy line 6 inches long.

APPENDIX III.

REPORT OF CAPT. BEVERLY W. DUNN, ORDNANCE DEPARTMENT, UPON THE ESTABLISHMENT OF A COURSE OF INSTRUCTION FOR ORDNANCE OFFICERS.

FRANKFORD ARSENAL,
Philadelphia, Pa., ——— —— —.

SIR: I have the honor to submit the following report pursuant to instructions contained in the following order and letter:

SPECIAL ORDERS, No. 286.

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, December 11, 1901.

[Extract.]

*　*　*　*　*　*　*

23. By direction of the Secretary of War, Capt. Beverly W. Dunn, Ordnance Department, will proceed to the places hereinafter specified on official business pertaining to the establishment of a course of instruction at the Sandy Hook Proving Ground, Sandy Hook, N. J., in the design and construction of ordnance, under such special instructions as he may receive from the Chief of Ordnance, and upon the completion of this duty will return to his proper station:

Massachusetts Institute of Technology, Boston, Mass.
Rensselaer Polytechnic School, Troy, N. Y.
Cornell University, Ithaca, N. Y.
Johns Hopkins University, Baltimore, Md.

The travel enjoined is necessary for the public service.

*　*　*　*　*　*　*

By command of Lieutenant-General Miles:

H. C. CORBIN,
Adjutant-General, Major-General, U. S. Army.

OFFICE OF THE CHIEF OF ORDNANCE,
UNITED STATES ARMY,
Washington, December 16, 1901.

SIR: The following special instructions are given for your guidance in carrying out your order to visit certain technical schools, issued from the Adjutant-General's Office on 11th instant.

It is desired to establish at the Sandy Hook Proving Ground a course of instruction for officers of the Ordnance Department which it is supposed will extend over about one year. This instruction will be both theoretical and practical. The theoretical instruction will include such subjects as will, in connection with their experience, fit the officers taking it for all duties in connection with gun construction, carriage construction, and their attendant mechanical features, and will include general mechanical engineering, electrical engineering, the chemistry of explosives, and optics. Practical instruction will be had in connection with the test and proof work of the proving ground, with the machine shop in performance of its ordinary functions and of such special functions as may be imposed upon it by the course now contemplated, with the electrical plant required for different proving ground purposes supplemented by such machines and appliances as may be added, and with the chemical laboratory which it is proposed to establish at the proving ground.

Your own experience will inform you as to the subjects, now taught at technical schools, which officers of the Ordnance Department may be supposed to be already proficient in, and also as to the subjects upon which they may need a slight review of their previous training. It is expected that instructors for the officers taking the course will be other officers having duties in connection with the proving ground, possibly including some of the assistant officers themselves. It is expected also that all officers taking the course of instruction will have duties in connection with the regular work of the proving ground, which will occupy a part of their time and the experience of which will constitute part of their instruction.

You will make a careful study of the methods of teaching the subjects in which the Department has an interest at the schools visited by you, noting their equipment in machines and other appliances with reference to making recommendations as to what shall be added at the proving ground. You will also examine their text-books, inform yourself as to their course of lectures, and generally make inquiries as to all the means which they employ to turn out from their establishments persons well prepared for the profession of engineering, especially in its mechanical branches. Bearing in mind the relative maturity, proficiency, and mental training of their students and our officers, you will submit a list of text-books, books of reference, machines and instruments required for the proposed course of instruction, together with any recommendations of a general nature which your visits and study of the subject may suggest.

In order that as early advantage as possible may be had of the result of your attention to this subject, it is desired that your report be submitted with as much promptness as is compatible with its being satisfactory to yourself.

Respectfully,

WILLIAM CROZIER,
Brigadier-General, Chief of Ordnance.

Capt. B. W. DUNN.
(Through the Commanding Officer, Frankford Arsenal.)

Before examining the data collected and attempting to formulate a plan for the instruction of ordnance officers, it is advisable to state in their proper sequence some well-known facts that will materially affect the problem.

The design and manufacture of war material constitutes one of the largest industries in the world, and its successful prosecution requires a great variety of special knowledge and skill.

As a rule, the great powers have within their territories thoroughly equipped plants, run by private enterprise, to which the government plants are subordinate in capacity. The United States must depend almost entirely on her Government plants, and, even when assistance is obtained from her private firms, the ordnance experts of the Army and Navy must furnish the designs, working drawings, and specifications.

It is evident, therefore, that ordnance officers should possess technical education of the highest order, and that specialization is necessary; for the range of this education, covering as it does several distinct professions, is too great for one mind to compass.

The knowledge required can be obtained by educating officers or hiring civilians, or combining the two methods, and the course of instruction of the officers will depend on the method selected and the division of duties. It will also depend on the status of the officer. If his proper work is to be in the line of the Army, his ordnance education should extend only so far as it will be of assistance to him as a line officer, and vice versa. Manufacturing and soldiering are too radically different to be combined in one successful vocation. The natural interpretation of the law establishing the detail system is that an officer's ordnance service will be limited to four years, and yet, by repeated details, his service with the line could be limited to almost four years. As much time as that, and more, can be spent in educating him; but, if this were done, his service in the first case would be

nonproductive in ordnance work. Even if his education be limited to one year, as proposed, instructors must be found, and the time of the capable officers of the Ordnance Department is now fully occupied. A visit to our first-class technical schools will emphasize the necessity for good instructors who can make the work of teaching their principal work. An officer already overloaded with work can not take up teaching as a side issue and pursue it successfully.

Technical education is naturally divided into three stages:

1. A solid foundation in mathematics and applied mechanics. This is potential only.

2. A broad comprehension of a given science, such as comes from reading closely and understandingly a good text-book. This increases individual culture.

3. Familiarity with all machines, appliances, and instruments pertaining to industrial applications of the science, and thorough training in the ready solution of all problems pertaining to their use. This makes the student an expert and gives commercial value to his knowledge.

To illustrate, a man may know a great deal about electrical engineering, be fairly well versed in theory, be qualified even to teach, and yet be entirely incapable of earning his living as a consulting electrical engineer. The Johns Hopkins University discontinued, about two years ago, its regular course in electrical engineering because other universities were able to devote more attention to this particular profession and offered superior facilities to the student. It continues to teach the theory and practice of electricity, using its efficient equipment of electrical machines and instruments, but all it claims to do is to equip men as teachers. The graduates of the best schools work in subordinate positions for years before acquiring that experience which enables them to handle successfully large problems in electrical engineering. Their knowledge and skill in their profession are then relatively complete, but to maintain their positions their experience and mental concentration must continue in this line—a general law affecting all technical professions.

Experts in mechanical engineering are more essential in the Ordnance Department than electrical experts, and the requirements in this profession are, at least, equally exacting.

Mistakes in the original establishment of a large plant are very expensive, and a machine may waste many times its cost by being relatively inefficient to start with or by inefficient operation.

This profession is usually divided into specialties, such as (1) the designing and installation of steam power plants and machinery, and (2) the superintendence of their operation to secure the maximum efficiency in quantity, quality, and cost of product.

Ordnance officers occupy positions of authority in manufacturing plants, and their knowledge should include the three stages mentioned if practicable. Heretofore it has been, in the average case, limited to the first stage, and the conditions have been unfavorable for rapid advance.

These conditions are:

1. The course at the Military Academy is practically limited to the first stage, and after several years' service in the line the most favorable assumption is that the young ordnance officer has reviewed his mathematics and mechanics, and so reacquired his scientific potential.

2. With no post-graduate instruction, his mind is not even in a receptive state. The dignity and authority of his position make it difficult for him to acknowledge his deficiencies to the practical men under him, and the temptation to conceal them is strong. The habit of depending upon these men for the knowledge and data required to answer the practical questions referred to him is easily acquired. He may then serve for years without material increase of proficiency in his practical knowledge of machinery. Golden opportunities to enlarge his knowledge, due to his official visits to the large private manufacturing establishments, are lost.

This does not imply that his career as an ordnance officer is a failure. It may, on the contrary, have been brilliantly successful. His mathematical proficiency or his inventive talent may have resulted in material improvements in ordnance, the draftsmen and mechanics under him supplying the practical knowledge and skill required.

There is ground for the contention that this mathematical and inventive work is not the proper technical field for the young ordnance officer; that mechanical, electrical, and other engineers and experts can be hired for less than the officer's salary; that, to be successful in their professions, these experts must devote their lives to their restricted fields of study, and that the officer must do likewise if he is to replace them; that he can not do this, for there are a multitude of other duties connected with the military, administrative, inspecting, testing, and investigating departments of his profession which must consume a large part of his time; that if we are to make efficient mechanical and electrical engineers of our officers their number must first be increased by an amount equal to the number of civilian employees displaced and the number of officers that would constitute a class under instruction; that incomplete instruction in a technical profession might add to the mental culture of the officer, but would not increase the practical value of his services, since we should still have to employ the civilian expert; that the weight of these arguments when applied to a permanent personnel must be largely increased when applied to temporary appointments.

In forming a general scheme for a post-graduate school for ordnance officers these arguments must receive due consideration. That they are essentially unsound in many respects is evident. It is also evident that we can not expect one average mind to do the work of half a dozen—one man to be proficient in many professions. A compromise must be effected. As much as possible, consistency with the conditions imposed must be taught, to enlarge the officer's potential capacity, to make his mind receptive of further instruction according to opportunities, to make him a competent judge of the quality of technical work done by others. Selection must be made of those departments in which his instruction must be thorough and at the expense, if necessary, of other less essential instruction.

Specializing must be accepted as a necessity. Some general instruction must be given to all, but as soon as practicable an officer should be assigned to a specialty and kept employed on it until the proper time comes for him to leave the constructive and enter the administrative branch of department work.

It is proposed (1) to state generally and in the order of precedence the kinds of technical knowledge that ordnance officers collectively should possess; (2) the scope of theoretical and practical instruction

given in the best technical schools, so far as applicable, and the time required by them to secure proficiency; and (3) a general plan for a school of instruction to meet given conditions.

I. Calculating strains and stresses in ordnance constructions, and fixing the proper dimensions of parts of guns, gun carriages, projectiles, etc.

Calculations in exterior and interior ballistics.

II. Mechanical drawing and preliminary tests to discover and develop talent for invention.

III. Systematic preservation of data for future reference; cultivation of brevity, force, and clearness of style in preparing official reports, preferably by dictation.

IV. History of the development of ordnance material and accurate information as to all modern types.

V. Chemistry, and manufacture of powders and high explosives.

VI. Practical application of the science of optics.

VII. Architecture of shop building, including drawing of plans and detailed specifications for erection of shop buildings to receive a given plant.

VIII. Installation, testing, and superintending the operation of steam and electric power plants to meet given conditions.

IX. Selection and installation of the best types of machines to do given work with the maximum of efficiency.

X. Machine shop superintendence as applied to the direction of the labor of a large number of men engaged in a variety of occupations.

In the above outline, I to VI, inclusive, show what the ordnance officers have been doing in the past and must do in the future; and VII to X the branches in which civilian experts can be most profitably employed.

The order of precedence would change if the number of officers in the corps, and the time and facilities available for instructing them, were greater.

COURSE AND METHOD OF INSTRUCTION IN ENGINEERING SCHOOLS.

THEORETICAL.

Mathematics, physics, acoustics, optics, applied mechanics, strength of materials.
Mechanical drawing.
General chemistry.
Principles of mechanism, gear teeth, machine tools.
Steam engineering, valve gears, thermodynamics, boilers and engines.
Theoretical electricity, electrical measuring instruments, and methods.
Technical applications of electricity, electric power, dynamo testing.
Theory of periodic currents, alternating generators and motors.
Dynamics of machines, and machine design.
Hydraulics.
Transmission and distribution of energy.

The above is the merest outline of the combined subject-matter of two courses, either of which requires four years from the student or five years for the two. A fresh graduate of the Military Academy could take the two courses in two years.

PRACTICAL.

I.

Carpentry, woodwork, pattern making.
Molding, foundry work, casting.
Forging and blacksmith work.
Metal turning, boring, milling, general machine work.

II.

Course in electrical measurements.
Testing strength of materials, boilers, engines, dynamos, electric and hydraulic motors, steam and water turbines.

At all the schools visited the general scope of the theoretical course is about the same. As a general rule, each professor teaches theory from data prepared in his department, and uses text-books on the market for reference. Their method of teaching by daily recitations and by lectures, and their regulations designed to secure attention and application from students are inapplicable to ordnance officers, who need only guidance, time, and facilities.

The maximum time allotted to I of the practical course is about nine hours per week, or a total of three hundred hours, and to II about six hundred hours for one course; or nine hundred hours for both electrical and mechanical engineering.

Work under I is entirely omitted at the Yale Scientific School, and the University of Pennsylvania has not yet introduced blacksmith work. Cornell University requires more under I than any other school, and has built a number of complete machines, engines, dynamos, pumps, etc., by student labor.

The following schedule shows the arrangement of the practical course in wood, metal, and foundry work in the mechanical engineering course of the University of Pennsylvania by Professor Spangler, a graduate of the Naval Academy. It will be noted that a progressive course of reference reading is prescribed in connection with the practical work. The production of skilled mechanics is not aimed at, only the principles underlying the trade. The average work produced is necessarily crude. Time is economized as much as possible. As an illustration, a planer exercise consists in setting a piece of metal for a given work. When the piece, tool, and stroke of machine are properly secured and adjusted, and a few cuts made, the lesson is complete, the finishing of the work being unnecessary. About three hundred hours are allotted in the shops to the entire schedule. This does not include the time devoted to reference reading and study.

Workshop exercises.

I. CARPENTERING.

No. 1. Bench tools, name, position. See instructor.

No. 2. Lumber, selection, grain, contraction, warping. (Read Rose Pattern Maker's Assistant, pp. 15–19, and Rose Machine Shop Practice, vol. 2, p. 264. Bulletin No. 10.)

No. 3. Sawing, rip and cross-cutting. (Read Shelley's Workshop Appliances, pp. 50–56; Rose Pattern Maker's Assistant, pp. 272 and 273; Disston, part 2, p. 3.)

No. 4. Grinding, jack and foreplanes, setting and oilstoning. (Read Shelley, pp. 42–49, and 65–74; Rose Machine Shop Practice, vol. 2, pp. 267 and 268; Rose Pattern Maker's Assistant, pp. 20–26.)

No. 5. Planing, straightening or winding.

No. 6. Gluing, soaking, heating, composition. (Read Appleton's Encyclopedia, p. 58.)

No. 7. Clamping, handscrews, pinchdogs.

No. 8. Form. Chisel grinding, draw motion, scribe knife, bench gauge, square, cutting block, bench hook, hack saw. (Read Shelley.) Glass paper numbers. (Read Rose Pattern Maker's Assistant, pp. 104 and 105.) Shellac varnish, composition. (Read Rose Pattern Maker's Assistant, pp. 112, 113, and 114.)

No. 9. Form. Inside ground gouges, draw motion, grinding, slipstoning, dividers, sharpening. (See Lockwood's Pattern Making, pp. 12, 13, 14, and 15.)

No. 10. Form. Outside ground gouges, draw motion, grinding, slipstoning, templates.

No. 11. Form. Use of reeding planes. General theory of plane cutters. (Read Appleton, vol. 2, pp. 545–548; Shelly, p. 49.) (*a*) Side bead, (*b*) center beads, (*c*) quarter round, (*d*) ogee, (*e*) reverse ogee.

No. 12. Joints. (*a*) Ledge, (*b*) plain corner, (*c*) miter corner, (*d*) plain center, (*e*) dovetail center, (*f*) brace.

No. 13. Form. Wood turning. Turning between centers, cutting tools, gouge, skew chisel, grinding. Slipstoning. (See Rose Pattern Maker's Assistant, p. 65–70.)

No. 14. Joints. Butt. (*a*) Corner offset, (*b*) corner butt, dowels, (*c*) brace set-ins.

No. 15. Form. Wood turning. Hollow spindle, scraping tools, grinding, oilstoning, chisel, diamond points, round nose. (See Shelley, pp. 149, 150, and 151.)

No. 16. Joints. Mortise and tenon. (*a*) Plain center, (*b*) center with wedges, (*c*) corner open, (*d*) corner hidden, (*e*) corner with wedges and dowels, (*f*) center with joint bolt, tongued and grooved. Boring, brace, auger, bitts. (See Shelley, pp. 58–65.)

No. 17. Form. Wood turning. Screw face plate, scraping tools. (*a*) Quarter round, (*b*) ogee, (*c*) reverse ogee, (*d*) Grecian ogee and bevel, (*e*) Grecian ovolo, (*f*) Grecian ogee and bead, (*g*) scotia, (*h*) cove.

No. 18. Joints. Dovetail. (*a*) Corner dovetail, (*b*) dovetail tie.

No. 19. Form. Wood turning. Cup turning and rechecking. Scraping tools. (*a*) Ogee, (*b*) Gothic, (*c*) ovolo.

No. 20. Joints. Timber splicing. Plain scarfs.

No. 21. Filing. Rip-saw. (Read Disston, part 2, pp. 3–13.) Dressing of teeth for soft woods, crowning.

No. 22. Jobbing. Construction of apparatus for laboratory.

II. Pattern Making.

No. 23. Shrink rule. Contraction, cast iron, brass, steel. (Read Lockwood's Pattern Making, pp. 2–5; Practical Iron Founding, pp. 15–18.)

No. 24. Dowels. Dowel plate, dowel turning.

No. 25. Fillets. Round planes, fillet forms. (Read Lockwood's Pattern Making, pp. 26 and 27.)

No. 26. Pattern. Solid. Carved or built up. Bench or lathe work. Drafting. (See Practical Iron Founding, p. 3.) Molding, theory. Practical iron founding, chap. 1. Rose Pattern Maker's Assistant, chap. 3.)

No. 27. Parted pattern. Carved from solid or built up. (Read Practical Iron Founding, chap. 3.)

No. 28. Filing rip saw. Sharpening and setting for soft woods. (See Disston.)

No. 29. Pattern. Green sand core. Solid pattern. Face plate turning.

No. 30. Pattern. Vertical. Dry sand core, core prints, core box, venting, roding. (Practical Iron Founding, pp. 39, 40, 41, and 42.)

No. 31. Pattern. Horizontal cores. Core boxes. Bench and lathe work.

No. 32. Pattern. Tail prints, finger pieces, bench and lathe work, core boxes, dry sand cores. (See Practical Iron Founding, pp. 87, 88, and 89.)

No. 33. Filing rip saw. Dressing teeth for hard cross-grained woods. (See Disston.)

No. 34. Patterns. Box fillets. (See Pattern Making, pp. 107–110.) Balanced dry sand cores, chaplattes. (See Practical Iron Founding, pp. 89–91.) Construction drawing, full size.

No. 35. Segment boxing. Cores without core prints, bow sawing, shooting board, bench work, and face-plate turning. (See Pattern Making, chap. 4.)

No. 36. Patterns. Drawback in core boxes, bench and lathe work.

No. 37. Pattern with two portings having drawbacks and skewer pins. Draw and rapping plates, floor molding, theory. (Practical Iron Founding, chap. 4 and 5.)

No. 38. Filing cross-cut saw. Dressing teeth for soft woods. (See Disston.)

No. 39. Patterns with two portings. Three-port flask. Molding. Alterations. Stop-off pieces. (See Iron Founding, chap. 4.)

No. 40. Patterns. Two portings. Three-port mold. Dry and green sand cores. Core plugs. (See Practical Iron Founding, chap. 4.)

No. 41. Patterns. Plate work. Open sand molding. Stop-off pieces. Dry sand cores and core boxes. (See Practical Iron Founding, chap. 4.)

No. 42. Filing cross-cut saw. Sharpening and setting for soft woods. (See Disston.)

No. 43. Patterns. Thin work. Follower board. Two-port mold turning and rechecking. (See Rose Pattern Maker's Assistant, pp. 189–192.)

No. 44. Pattern alterations of iron patterns. Dry sand cores. Core boxes and stop-off pieces. (See Instructor.)

No. 45. Filing crosscut saw. Dressing of teeth. Setting and sharpening for hard woods. (See Disston.)

No. 46. Patterns. Three or more partings. Cores supporting each other. Chaplettes. (See Lockwood's Pattern Making, chap. 9, and Principles of Pattern Making, chap. 5.)

At all the schools visited the general scope of the theoretical course is about the same. As a general rule, each professor teaches theory from data prepared in his department, and uses text-books on the market for reference. Their method of teaching by daily recitations and by lectures, and their regulations designed to secure attention and application from students are inapplicable to ordnance officers, who need only guidance, time, and facilities.

The maximum time allotted to I of the practical course is about nine hours per week, or a total of three hundred hours, and to II about six hundred hours for one course; or nine hundred hours for both electrical and mechanical engineering.

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No. 5. Planing, straightening or winding.

No. 6. Gluing, soaking, heating, composition. (Read Appleton's Encyclopedia, p. 58.)

No. 7. Clamping, handscrews, pinchdogs.

No. 8. Form. Chisel grinding, draw motion, scribe knife, bench gauge, square, cutting block, bench hook, hack saw. (Read Shelley.) Glass paper numbers. (Read Rose Pattern Maker's Assistant, pp. 104 and 105.) Shellac varnish, composition. (Read Rose Pattern Maker's Assistant, pp. 112, 113, and 114.)

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No. 10. Form. Outside ground gouges, draw motion, grinding, slipstoning, templates.

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No. 23. Shrink rule. Contraction, cast iron, brass, steel. (Read Lockwood's Pattern Making, pp. 2–5; Practical Iron Founding, pp. 15–18.)

No. 24. Dowels. Dowel plate, dowel turning.

No. 25. Fillets. Round planes, fillet forms. (Read Lockwood's Pattern Making, pp. 26 and 27.)

No. 26. Pattern. Solid. Carved or built up. Bench or lathe work. Drafting. (See Practical Iron Founding, p. 3.) Molding, theory. Practical iron founding, chap. 1. Rose Pattern Maker's Assistant, chap. 3.)

No. 27. Parted pattern. Carved from solid or built up. (Read Practical Iron Founding, chap. 3.)

No. 28. Filing rip saw. Sharpening and setting for soft woods. (See Disston.)

No. 29. Pattern. Green sand core. Solid pattern. Face plate turning.

No. 30. Pattern. Vertical. Dry sand core, core prints, core box, venting, roding. (Practical Iron Founding, pp. 39, 40, 41, and 42.)

No. 31. Pattern. Horizontal cores. Core boxes. Bench and lathe work.

No. 32. Pattern. Tail prints, finger pieces, bench and lathe work, core boxes, dry sand cores. (See Practical Iron Founding, pp. 87, 88, and 89.)

No. 33. Filing rip saw. Dressing teeth for hard cross-grained woods. (See Disston.)

No. 34. Patterns. Box fillets. (See Pattern Making, pp. 107–110.) Balanced dry sand cores, chaplattes. (See Practical Iron Founding, pp. 89–91.) Construction drawing, full size.

No. 35. Segment boxing. Cores without core prints, bow sawing, shooting board, bench work, and face-plate turning. (See Pattern Making, chap. 4.)

No. 36. Patterns. Drawback in core boxes, bench and lathe work.

No. 37. Pattern with two portings having drawbacks and skewer pins. Draw and rapping plates, floor molding, theory. (Practical Iron Founding, chap. 4 and 5.)

No. 38. Filing cross-cut saw. Dressing teeth for soft woods. (See Disston.)

No. 39. Patterns with two portings. Three-port flask. Molding. Alterations. Stop-off pieces. (See Iron Founding, chap. 4.)

No. 40. Patterns. Two portings. Three-port mold. Dry and green sand cores. Core plugs. (See Practical Iron Founding, chap. 4.)

No. 41. Patterns. Plate work. Open sand molding. Stop-off pieces. Dry sand cores and core boxes. (See Practical Iron Founding, chap. 4.)

No. 42. Filing cross-cut saw. Sharpening and setting for soft woods. (See Disston.)

No. 43. Patterns. Thin work. Follower board. Two-port mold turning and rechecking. (See Rose Pattern Maker's Assistant, pp. 189–192.)

No. 44. Pattern alterations of iron patterns. Dry sand cores. Core boxes and stop-off pieces. (See Instructor.)

No. 45. Filing crosscut saw. Dressing of teeth. Setting and sharpening for hard woods. (See Disston.)

No. 46. Patterns. Three or more partings. Cores supporting each other. Chaplettes. (See Lockwood's Pattern Making, chap. 9, and Principles of Pattern Making, chap. 5.)

III. Molding.

ORDER OF EXERCISES.

No. 1. Molding tools. Names. (See Book of Tools, pp. 286–290; West's vol. 1, pp. 94–100; Practical Iron Founding, pp. 19–30.)

No. 2. Molding sand. Green. Dry. Core. Loam. Parting. Facing. Composition. (Read Practical Iron Founding, pp. 31–34; West's Iron Founding, pp. 347–363, vol. 1.)

No. 3. Melting. Cast iron. Steel. Brass. (Read Practical Iron Founding, pp. 174–182; West's vol. 1, pp. 289–306; West's vol. 2, pp. 265–272, 282–286, 301–320; Bolland, Iron Founding, pp. 23–34, 346–353.)

No. 4. Molding from solid pattern. Ramming. (Read West's vol. 2, pp. 134–139.) Fins. (West's vol. 2, pp. 95–100.) Vents. (West's vol. 2, pp. 101–107.)

No. 5. Molding from parted patterns. (Practical Iron Founding, pp. 35–37.) Draft. (Practical Iron Founding, p. 3.) Contraction. (West's vol. 1, pp. 248–260.)

No. 6. Molding from patterns leaving green sand cores. Cores. Green. Dry. Horizontal. Vertical. Venting. (See West's vol. 2, pp. 108–113.) Arbors. Rods. Grids. Spiders. (West's vol. 2, pp. 140–155; Practical Iron Founding, pp. 78–86.)

No. 7. Molding from patterns having cope and drag prints. Standard core boxes. (See Instructor.) Gates. Pouring. Skimming. Burning. Risers. (Practical Iron Founding, pp. 48–58; West's vol. 2, pp. 120–133.)

No. 8. Molding from patterns having balanced prints. (Practical Iron Founding, pp. 86–93.) Chaplettes. (West's vol. 1, p. 343.)

No. 9. Molding from patterns having tail prints. Finger pieces. Drawbacks. Skewer pins. (Read Practical Iron Founding, pp. 78–90.)

No. 10. Molding from patterns having two or more partings. Three-part flask. Green or dry sand cores. (See Instructor; Practical Iron Founding, p. 35.)

No. 11. Molding from patterns having dry sand cores supporting each other. Floor molding. Bedding in. (Read West's vol. 1, pp. 27–29, 81–89; Practical Iron Founding, p. 33.) Soldiers. Jaggers. Cinder beds. (Read West's vol. 1, pp. 81–89.) Weighting and clamping of molds. (West's vol. 1, pp. 111–116; West's vol. 2, pp. 187–207.)

No. 12. Molding from patterns having stop-off pieces. (Read West's vol. 2, pp. 48–71.) Alteration of iron patterns by cores and stop-offs. (See Instructor.) Warping of castings. (West's vol. 1, pp. 282–288; Rose Pattern Maker's Assistant, pp. 244–247; Practical Iron Founding, pp. 15–18.)

IV. Iron Shop.

No. 1. Names and uses of bench tools:

Vise. (Rose, vol. 2, pp. 62–64.)

Hammer. (Rose, pp. 64–73.) Notice figures 2142–2148 for use of peen. (Shelley, p. 74.)

Chisels. Name and shape. (Rose, vol. 2, pp. 73–76.) Grinding. (Appleton, vol. 1, p. 351.) Use of. (Shelley, pp. 74–76.)

Files. Names and cut. (Rose, vol. 2, pp. 86–91, and Shelley, pp. 76–84.) Use of. (Rose, vol. 2, pp. 92–95; Shelley, pp. 125–130.)

Square. (Appleton, vol. 2, p. 787; Rose, vol. 1, pp. 379, 380, figs. 1460–1469.)

Bevel square, or protractor. (Rose, vol. 1, pp. 380, 381, figs. 1470–1472.)

Hexagonal nut gauge. (Rose, vol. 2, pp. 104, 105; vol. 1, p. 381, fig. 1473.)

Calipers. (Appleton, vol. 1, pp. 297–299; Rose, vol. 1, pp. 360–363, 378, figs. 1454–1456.)

Scale and rule. (Appleton, vol. 2, pp. 686, 687.)

Keyway square. (Appleton, vol. 2, p. 687, fig. 3710; Rose, vol. 1, p. 378, fig. 1457; Rose, vol. 2, p. 101, fig. 2279.)

Scrapers. (Rose, vol. 2, pp. 97, 98; Shelley, pp. 106–107.)

Scratch gauge.

Surface gauge. (Rose, vol. 1, p. 378, fig. 1458; Shelley, p. 121.)

Dividers. (Rose, vol. 1, pp. 377–378, figs. 1449–1453.)

No. 2. Setting work in vise. (Shelley, p. 129; Rose, vol. 2, pp. 102–104.)

No. 3. Use of cape chisel: Cape out slots in block of cast iron. (Rose, vol. 2, p. 76, fig. 2176.)

Use of flat chisel: Finish one face of cast iron block with chisels only. (Rose, vol. 2, p. 76, fig. 2176.)

No. 4. Use of files: Finish opposite side of cast-iron block with chisels and file. (Shelley, pp. 126–130.)

No. 5. Use of square and calipers. (Rose, vol. 1, pp. 360–363, 379–380.) True up sides and ends of cast-iron block, with file-finished side, to dimensions. Scrape one end and one side. Emery finish other side and end.

No. 6. Grinding chisels for use on wrought iron or steel. (Rose, vol. 1, p. 74, between figs. 2154 and 2155.) Finish two sides of wrought-iron block, parallel and square, with chisels only, using scratch gauge and keyway square to lay out work.

No. 7. Grinding chisels for use on brass. Reference as for article No. 6. Finish two opposite sides of brass hexagon nut with chisels only, using calipers to get parallel.

No. 8. Filing brass. See Instructor. (Shelley, p. 126.) Finish four sides of brass hexagon nut with chisels and file, using calipers and bevel square or nut gauge.

No. 9. Dressing and tempering tools. (See Shelley, pp. 314–326, p. 362; see Appleton, vol. 2, frontispiece and pp. 863, 868; see Rose, vol. 2, pp. 460, 461.)

No. 10. Corner fitting, corner. Two surfaces fitted together.

No. 11. Cutting and threading machine bolts and finishing heads. Taps and dies. (Appleton, vol. 2, pp. 730, 732; Rose, vol. 1, pp. 97–110; Shelley, pp. 95–102; Appleton, vol. 2, p. 729.)

Standard pitches for threads. (Rose, vol. 1, pp. 95, 114.)

Forms of screwthreads. (Rose, vol. 1, p. 85, pl. 2.)

No. 12. Use of drill press. (Rose, vol. 1, pp. 428–435; Shelley, pp. 205–227.)

Drills, names and shapes. (Rose, vol. 1, pp. 274–279, 442–444; Shelley, pp. 84–89, 221.)

Drills, grinding. (Rose, vol. 2, pp. 41–44; Shelley, pp. 86–89, 222, 228–229.)

Laying out and drilling to patterns.

No. 13. Drilling for inside fitting. Laying out and use of chisels and files on inside work.

No. 14. Speeds of drilling. Effect of changing speeds. Table. (Rose, vol. 1, p. 277.)

No. 15. Keyway work. Open end, use of chisels, files, calipers, and keyway square. (Rose, vol. 2, pp. 106–109.)

No. 16. Keyway work. Inside. Drill, press, etc. (Rose, vol. 2, p. 108.)

No. 17. Pipe work. Tools for cutting off. (Rose, vol. 2, p. 142.)

Names of fittings. (McFadden's Catalogue, p. 1053 to end.)

Taps and dies. (Rose, vol. 1, p. 106, fig. 350; Appleton, vol. 2, p. 733.)

Standard pitches of pipe threads. (Rose, vol. 1, pp. 95–96; Appleton, vol. 2, pp. 729, 730.)

Cutting right and left hand threads.

No. 18. Cutting short nipples. Measuring for and fitting in pipe.

No. 19. Lathe. Centering and straightening work. (Rose, vol. 1, pp. 300–304.)

No. 20. Hand lathe. (Rose, vol. 1, p. 191.) Use of roughing tools. (Rose, vol. 1, pp. 330–335; Shelley, p. 156; Appleton, vol. 2, pp. 260–266.)

No. 21. Use of hand finishing tools. (Rose, vol. 1, pp. 330–335; Shelley, p. 155.)

No. 22. Finishing threads with hand chaser. (Rose, vol. 1, pp. 335–338; Shelley, pp. 159, 160; Appleton, vol. 2, pp. 266–268.)

No. 23. Chucking. Turning. Boring and facing with hand tools. (Shelley, pp. 148–152; Appleton, vol. 2, pp. 249–255.)

No. 24. Machine lathes. (Rose, vol. 1, pp. 254–273; Shelley, pp. 177–193; Appleton, vol. 2, pp. 242–247.)

Tools, names and uses. (Rose, vol. 1, pp. 254–273; Shelley, pp. 200–204; Appleton, vol. 2, pp. 267–274.)

Tools, grinding. (Rose, vol. 1, pp. 254–268; Shelley, p. 201.)

No. 25. Parallel and shoulder turning hand feed.

No. 26. Study of slide rest. (Rose, vol. 1, pp. 132, 137, 146, 168–170; Shelley, pp. 194, 195.)

Apron. (Rose, vol. 1, pp. 138, 146, 170, 171; Shelley, pp. 194, 195.)

No. 27. Turning piece using cutting off tools. (Rose, vol. 1, p. 262.)

No. 28. Study and sketch of gearing for cutting threads called for. (Rose, vol. 1, pp. 177–181, 319–324; Shelley, pp. 182, 183; Appendix, Table 8.)

No. 29. Cut one thread complete and others part way.

No. 30. Facing. Use of side tools. Rose, vol. 1, p. 263; Appleton, vol. 2, p. 272.)

No. 31. Speeds. Effect of varying. (See Instructor.)

No. 32. Boring and inside chasing. (See Instructor.)

No. 33. Turning cylindrical for a forcing fit.

No. 34. Turning cylindrical for a running fit. (Rose, vol. 1, pp. 362–367.)

No. 35. Turning cylindrical for a shrink fit.

No. 36. Planer. (Rose, vol. 1, p. 406; Shelley, pp. 236–259; Appleton, vol. 2, pp. 548–552.)

Tools, names and uses. (Rose, vol. 1, pp. 422–427; Shelley, pp. 259, 260, 266; Appleton, vol. 2, p. 552.)

Tools, grinding. (Rose, vol. 1, pp. 422–427.)
No. 37. Setting work on planer for top and side planing. (Rose, vol. 1, pp. 418–423.)
No. 38. General use of planer, method of setting tools for all uses. (Rose, vol. 1, pp. 424–427.)

Of the two divisions of the practical courses, II is by far the most important, although the necessity for that familiarity with machines which comes only from handling them can not be avoided.

The following schedule of practical work in the course of electrical measurements is followed at the Massachusetts Institute of Technology. A theoretical study of the instrument involved precedes each piece of work. The student submits in writing the data obtained in each case, and neat, systematic methods of recording results are inculcated.

ELECTRICAL MEASUREMENTS.

Simple galvanoscopes.
Resistance by substitution.
Slide wire bridge.
Wheatstone bridge.
Points relating to the bridge.
Applications of the bridge principle.
Low-resistance bridge.
Temperature corrections in resistance measurements.
Values of the ohm.
Tangent galvanometer.
Coefficient of torsion.
Calibration of secondary galvanometers.
Calibration by Ohm's law.
Calibration by standard galvanometer.
Measurement of current by electrolysis.
Sensitive reflecting galvanometer.
Edelmann magnetometer.
Kohlrausch magnetic variometer.
Kew portable magnetometer.
Magnetic inclination or dip.
E. M. F. and B. of batteries.
Electrostatic capacity.
High-resistance measurement.
Insulation resistance.
Cable testing.
Differential galvanometer.
Specific resistance; conductivity.
Specific resistance by wheatstone bridge.
Specific resistance, special method.
Voltmeter calibration by Clark cell.
Large current measurement by Clark cell.
Ammeter calibration.
Permeability of iron.
Magnetometer method for permeability
Yoke method for permeability.
Ring method for magnetization of iron.
Inductance measurement.
Inductance, Rowland's method.
Efficiency of transformers by wattmeters.
The legal electrical units in the United States.

This is followed by a course in general electric testing, testing of dynamos, motors, transformers, electric lamps, etc. The student becomes thoroughly familiar with producing, transmitting, changing, and measuring electric currents under all conditions.

The following schedule shows the mechanical engineering laboratory work at the Massachusetts Institute of Technology:

Tests of the transmission of power by belting.
Tests of the performance of a surface condenser.

Tests of a direct-acting steam pump.
Tests to determine the accuracy of planimeters.
Tests to determine the accuracy of indicator springs.
Tests of a 36-horsepower gas engine.
Tests to determine the efficiency of jackscrews.
Tests to determine the efficiency of pulley blocks.
Tests of the flow of steam.
Valve setting (plain slide valve).
Tests of a pulsometer.
Tests of a centrifugal pump.
Calibration of orifices for the flow of water.
Determination of the clearance of an engine.
Use of the Emerson power scale.
Valve setting (double valve).
Tests of gauges by means of the mercury column.
Tests of a 208-horsepower boiler, the test continuing for one hundred and four hours, each man working eight hours.
Tests of the steam injector.
Use of three different kinds of calorimeters.
Tests of a Swain turbine.
Tests of a rotary pump of a capacity of 1,000 gallons per minute.
Measurement of the flow of water by means of orifices and weirs.
Test of a 48-inch Pelton water wheel.
Tests of a Rider hot-air engine.
Tests of an Ericsson hot-air engine.
Valve setting (Harris-Corliss engine).
Analysis of chimney gas.
Explosive force and time of reaching maximum pressure of different mixtures of gas and air.
Ratio of specific heats of air.
Tests of a battery of boilers of 200 horsepower, each test lasting twenty-four hours, each student working eight hours.
Application of Hirn's analysis to the triple-expansion engine in the laboratory, run as a compound engine.
Forty-five-hour test on the engines, boilers, and generators at the Harvard Square power station of the Boston Elevated Railway Company, with four watches, each of eleven and a quarter hours, by a squad of 25 students.

The graduates of the Naval Academy selected for training as naval constructors are now sent to this institution instead of abroad, and a special course has been arranged there for them. Professor Lanza and his principal assistant, Professor Miller, were consulted to obtain their estimates of the time a young West Point graduate would need to take their course in mechanical engineering. Under the most favorable assumptions they placed it at one school year, or two terms, and at least one extra term if he wished to take also the course in electrical engineering. This estimate is based upon their facilities in equipment and trained instructors.

What has been said concerning the theoretical and practical work in schools is intended to present an outline only. Any details desired can be learned from the catalogues and text-books. They would confuse the general impressions desired if presented here.

INSTRUCTION OF ORDNANCE OFFICERS.

The conditions imposed, viz, the location of the school at the proving ground, the limiting of the course to one year, with a considerable portion of this devoted to routine proving-ground work, the limited equipment, the use of officers actively engaged in other work as instructors, would restrict the scope of instruction, even if such restriction were not advisable for other reasons.

Under these conditions we can not expect to produce efficient mechanical and electrical engineers, and yet we can teach more than

the average officer has learned during his entire service under the "no instruction" system. The school will have to grow and the amount of instruction possible will be determined by experience. The equipment will also grow, even with no special appropriation to provide it. A machine-shop plant, superior in some respects to any possessed by technical schools, is already installed, and additions to it will be required for regular work. The electric generators and motors now being supplied for operating the Gantry crane furnish everything needed in this line for direct-current electricity. The chemical laboratory already provided for will require only the addition of a small plant to manufacture smokeless powder in experimental lots.

The synopsis of ordnance instruction required will now be considered in detail.

I. CALCULATIONS OF STRAINS AND STRESSES IN ORDNANCE CONSTRUCTION AND FIXING THE PROPER DIMENSIONS OF PARTS OF GUNS, GUN CARRIAGES, PROJECTILES, ETC.—CALCULATIONS IN EXTERIOR AND INTERIOR BALLISTICS.

The student is assumed to have reviewed his mathematics and applied mechanics. It is essential that he do this before attempting further progress. Ability to make these calculations is of the first importance, and they will test the efficiency of his review.

Sample calculations for all important constructions, with references to enable the student to verify and study the demonstrations of all formulas used, should be prepared. Each student should be required to solve similar problems with different data. Officers in the Department who have made specialties of designing guns, gun carriages, projectiles, fuzes, etc., could supply the sample calculations required to start the course, and in a short time the work of the students themselves would supply the necessary supplementary data to enable the Department to publish a Handbook of Ordnance Calculations—a book that would be very useful to the service, and especially to young officers in the line who desire ordnance work and who wish to prepare themselves for it. In connection with this Handbook, a revision of the Ordnance Manual should be prepared for publication.

The time required to complete this course would be considerable at first, but would rapidly decrease, especially after publication of the Handbook. The experience already acquired at the Ordnance Office in training officers in gun-carriage calculation and design would indicate the time required. Even if the first class receive thorough instruction in this course only, combined with superficial instruction in other branches, a satisfactory start will have been made.

Extended work in the actual solution of problems, instead of limiting the student to explaining how to solve them, constitutes the most conspicuous difference between the system of instruction at the schools visited and the system followed at the Military Academy.

The latter is rendered necessary, probably, by the required extent and variety of a cadet's instruction, and by his limited progress at the beginning, but the results of the former system are more satisfactory.

After reviewing their previous instruction, all student officers should be proficient in exterior and interior ballistics, but their course in problems should include these branches. Calculations in interior ballistics should include calculations of maximum theoretical force and temperature of explosion of any explosive mixture or compound.

II. MECHANICAL DRAWING AND PRELIMINARY TESTS TO DISCOVER AND DEVELOP TALENT FOR INVENTION.

The most valuable qualification of an ordnance officer is a talent for sound and practical invention. This talent can not be taught, but it can be developed and directed into safe channels, and as mathematical training is the best tool for this purpose, and is the foundation for all ordnance work, it is given first place in the curriculum. True talent must be discovered, encouraged, and directed; the officer who is not original, or is unsound in his originality, must be convinced of that fact as early as possible. Further instruction is necessary for the development of the inventor, and all that is expected at this stage is to discover whether the talent exists.

Instruction and practice in reading and making mechanical drawings naturally follow the course in calculations, and they can be utilized to test the student's inventive talent as well as to familiarize him with the service types of ordnance.

The course should consist almost entirely of problems. From general drawings the student should prepare rough drawings of the details of component parts, and he should be required to detect errors purposely inserted in the details of working drawings. The problems should be progressive and should include all service types. An important part of the work required should be the dictation to a stenographer of descriptions of the types, with his criticisms of their efficiency. Dictation is an excellent exercise to develop rapidity and clearness of thought.

The immense volume of work accomplished in conducting correspondence and rendering reports by the heads of departments in modern manufacturing establishments is made possible only by the universal use of stenographers.

To acquire the faculty of using one is to acquire the faculty of speaking extemporaneously with brevity and clearness. Few officers have it, and they should begin early to seek it.

By requiring students (1) to submit other devices to do the work of those shown by the drawings studied and (2) new designs, complete, of mechanisms to meet given conditions, the degree of inventive talent possessed by them can be tested. Further exercises in this line should be given those who show indications of useful originality. The impression should not be given that only inventors are of use in ordnance work, for this is not true, and the majority of the students would either be hopelessly discouraged or induced to waste valuable time. The great volume of ordnance work consists in getting the best practical results in ordnance material by using established ideas and methods, admitting improvements, but gradually and conservatively. The officer who is continuously trying to improve by radical changes everything he comes into contact with must be a genius not to make expensive mistakes. His life is generally unenviable, for he is sure to overtax his energy. Combine his tendency to invention with practical unsoundness, and we have an extreme example to be avoided by the training herein proposed, the object of which would be either to remove his unsoundness and temper his enthusiasm, or to convince him that invention is not the field for his energy.

The opposite extreme, more dangerous to progress and more to be avoided, is the man who objects to all attempts of officers to improve old and invent new ordnance material.

III. SYSTEMATIC PRESERVATION OF DATA FOR FUTURE REFERENCE—CULTIVATION OF BREVITY, FORCE, AND CLEARNESS OF STYLE IN PREPARING OFFICIAL REPORTS, PREFERABLY BY DICTATION.

The average young ordnance officer is liable to waste a great deal of time in searching for data and information that were at one time in his possession. A suitable system for the orderly preservation of such information, the officer's official correspondence, information from professional reading, etc., should be prescribed, and each officer required to practice it.

The dictated descriptions of types of ordnance material suggested in the preceding section and all other reports rendered by the student officer should be criticised with a view to improvement of his style.

No considerable amount of time can be spent for instruction under this head, and in no sense is a course in literature intended. The points involved are of sufficient importance to merit mention among the general qualifications desired, that both students and instructors may profit by all opportunities to cultivate them.

IV. HISTORY OF THE DEVELOPMENT OF ORDNANCE MATERIAL AND ACCURATE INFORMATION AS TO ALL MODERN TYPES.

This heading is intended to cover a general course of professional reading. It requires (1) the creation of a professional library at the school with provisions for keeping it up to date, (2) the preparation and maintenance by the students of a complete card catalogue of the library, and (3) the laying out by instructors of a regular schedule of reading for the student, designed to supply him progressively with the general information desired. It is not expected that all of this reading can be done at the school. During the student's subsequent service at arsenals it will be of great service to him to have such a schedule telling him what to read and in what order.

The list of professional periodicals supplied to the library should be complete, and card indexes of the contents of each should be prepared by the students as soon as received. These cards should be accompanied by a synopsis of the substance of important articles, the synopsis to be dictated by the student after a careful study of the article. A list of technical works for use as text-books and books of reference is given in Appendix A.

V. CHEMISTRY AND MANUFACTURE OF POWDERS AND HIGH EXPLOSIVES.

The Department now has a complete and modern laboratory outfit for testing, analyzing, and investigating powders and explosives. A suitable building to be erected at the proving ground has already been allowed, and if a plant for manufacturing smokeless powder in experimental quantities is provided the entire outfit will be comparable with that recently established at Neubablesberg, Germany, and generally recognized as the leading laboratory of its kind in the world.

The proposed course in this department will be (1) a general course of reading, to include: Remsen, Introduction to Study of Chemistry; Sanford, Nitroexplosives; Cross & Bevan, Cellulose; (2) selections from reference books on manufacture of sulphuric and nitric acids, solvents, and other materials used in manufacture of nitrocellulose and smokeless powders; (3) a more advanced course in thermo chemistry of powders, to include selections from Berthelot, Gody &

Chalon, with practical problems in calculating maximum theoretical power and temperature of explosion of any explosive mixture or compound, dimensions of grains of smokeless powder, and chamber capacities for given conditions of caliber, pressure, velocity, etc., and (4) practical laboratory work, to include:

(*a*) Stability or heat test with all forms of apparatus on hand.
(*b*) Determination of specific gravity, gravimetric density, moisture and solvents, acidity or alkalinity, solubility, hygroscopicity, etc., of powders.
(*c*) Nitrometer tests with different forms of apparatus.
(*d*) Qualitative and quantitative analyses of powders and high explosives.
(*e*) Impact, fragmentation, stability, and other tests of high explosives.
(*f*) Use of calorimeters, explosive bombs, analysis of products of explosion, etc.
(*g*) Actual manufacture in experimental quantities of smokeless powders and high explosives.

It is expected that the inspector of powder, with his assistant officers and chemists, will utilize the laboratory plant to advance the science of powder manufacture through original investigation carried on in close touch with the powder manufacturers.

The proving-ground facilities for testing experimental lots of powder promptly and the complete equipment of instruments for tests and investigations will make this laboratory the natural place for originating improvements in powder manufacture and testing those suggested elsewhere.

VI. PRACTICAL APPLICATIONS OF THE SCIENCE OF OPTICS.

The average student will not have time at the school to make a thorough review of the mathematical work given in the course in optics at the Military Academy. This can be done later by those who have a special interest in the science, and it must be done by those who desire to make a specialty of designing telescopic sights and other pointing instruments.

Practical instruction in the methods of constructing, testing, and adjusting the service models of telescopic sights is essential.

No suitable text-book for this course is known to the writer, but Messrs. Warner & Swasey Company, who make these sights, have informed him that they contemplate preparing a pamphlet for the purpose.

A list of apparatus required for practical instruction is given in Appendix C to this report. It includes an optical bench, with an outfit of lenses, prisms, and eyepieces, to enable the student to study the effect of different combinations on power, field, etc., and a complete plant for testing and adjusting the service models of telescopic sights.

The preceding sections include those branches of ordnance education wherein (excepting the services of expert chemists) we must depend entirely upon the officers. The following sections are of prime importance, but they represent branches in which civilian expert knowledge can always be obtained and must be relied on to a great extent, (1) because officers can acquire the requisite knowledge and skill only by taking courses of instruction far more extended than could possibly be given at Sandy Hook under the conditions imposed; (2) because each officer would have to devote his entire service to one specialty, as do the civilian experts, a condition antagonistic to the detail system, and (3) the present commissioned strength of the Ordnance Department would not permit the detachment of the considerable number of officers that would be necessary to replace civilian experts and supply the students.

This is stated to explain the curtailment of instruction recommended when compared with that given by technical schools.

VII. ARCHITECTURE OF SHOPBUILDING.

Careful study of a work, such as the pamphlet prepared by Professor Main for use of the students in the engineering course at the Massachusetts Institute of Technology, will supply a foundation of knowledge sufficient to enable the officers to handle all except the very large problems in shop design and construction. During his subsequent service at arsenals where construction work of this kind is going on he will have opportunities to increase his knowledge.

VIII. INSTALLATION, TESTING, AND SUPERINTENDING THE OPERATION OF STEAM AND ELECTRIC POWER PLANTS.

The object of this course will be to give the student a general theoretical and practical knowledge of boilers, steam engines, dynamos, and motors for both direct and alternating currents, and the instruments used in testing them.

Boilers.—Read carefully Peabody & Miller's work on The Steam Boiler.

Make an eight hours' test of the largest boiler in use at the proving ground.

Steam engines.—Read carefully Thermodynamics of the Steam Engine, Valve Gears, and Steam-Engine Indicator, by Peabody, or other modern text-books. Make at least three indicator card tests of steam engine and work up the results, using a mechanical integrator.

Electric generators, transformers, and motors.—Read Steinmetz's Theoretical Elements of Electrical Engineering, Thompson's Dynamo-Electric Machinery and Polyphase Electric Currents, Steinmetz's Alternating Current Phenomena, Fleming's Alternating Current Transformers, and Bell's Electric Transmission of Power.

Acquire by frequent use practical familiarity with the use of resistance coils, galvanometers, Wheatstone bridge, voltmeters, ammeters, and wattmeters for direct and alternating currents. Regular exercises should be arranged by the instructor for each of these instruments.

The student should in his practical work trace and measure all transformations of energy through the agencies of the boiler, engine, dynamo, transformer, and storage battery. The greater part of the physical laboratory work required by the technical schools, the testing and calibration of instruments, etc., will have to be omitted. The general course of reading prescribed will give him the theory of all such work and enable him during his subsequent service, when time is available, to pursue further any particular branch that interests him or that his special duties may require him to know more of.

A list of machines, apparatus, and instruments required in addition to those already at the proving ground is given in Appendix B to this report.

IX. SELECTION AND INSTALLATION OF THE BEST TYPES OF MACHINES TO DO GIVEN WORK WITH THE MAXIMUM OF EFFICIENCY.

Study Notes on Mechanism and Notes on Gearing, by Professors Schwamb and Merrill; Dynamics of Machines, by Professor Lanza; Manual of Machine Drawing and Design, by Professors Laws and Brevis, or similar works.

Study from drawings the construction of standard types of metal-working machines, lathes, turret screw machines, automatic screw machines, planers, milling machines, drill presses, etc.

For practical work follow the University of Pennsylvania schedule, given on pages 105 to 108 herein. The foremen of carpenter and machine shops should be utilized for this instruction. If the one year allotted does not allow the time necessary for this very essential practical work, the student should be required to take up the schedule and complete it at the first arsenal of construction to which he is sent.

X. MACHINE-SHOP SUPERINTENDENCE AS APPLIED TO THE DIRECTION OF THE LABOR OF A LARGE NUMBER OF MEN ENGAGED IN A VARIETY OF OCCUPATIONS.

This is important and must be included in any general list of the duties of the Ordnance Department. It is not practicable to introduce in a one year's course, so crowded with other matters, any systematic instruction. The general course of reading prescribed should include references to works on this subject, and lectures should be given during the school term by officers and the practical engineers and shop superintendents employed by the department.

COURSE OF LECTURES.

A course of lectures, to be attended by all students and officers connected with the proving ground, should constitute an important feature of the school. Officers of the Department who have made specialties of ordnance investigation, design, or construction; army officers of the line with valuable experience in the use of ordnance material, enabling them to specify good, bad, and desirable qualities from the standpoint of the user of such material; officers of the Navy and prominent men from civil life engaged in manufacturing, electrical or mechanical engineering, should be utilized, as far as practicable, to furnish these lectures.

Copies, or stenographic reports, of lectures and discussions should be sent to all ordnance officers.

INSTRUCTION AT ARSENALS.

Provision must be made for continuing this instruction at the arsenals. Some system is needed also to guide the study of officers now in the Department who will not have an opportunity to take the course of instruction at the proving ground. An ambitious officer will study to better advantage under intelligent supervision to accomplish specified tasks. The examination preceding promotion is not a sufficient stimulus to secure his best effort.

The successful operation of the large correspondence schools illustrates the assistance that can be given in self-culture by distant supervision.

The instruction recommended by practical problems in ordnance calculations, in reading, correcting, completing, or improving mechanical drawings of ordnance types, could be imparted by correspondence to officers at arsenals as well as at the proving ground.

Three of our arsenals, Watertown, Watervliet, and Frankford, are near engineering schools—Massachusetts Institute of Technology, Rensselaer Polytechnic, and University of Pennsylvania. Arrangements could readily be made to secure for officers the use of the equipments of these schools for practical instruction.

An officers' workshop should also be provided at each arsenal, containing type machines and separated from the regular shops.

TIME REQUIRED FOR STUDY AND PRESENT COMMISSIONED STRENGTH OF ORDNANCE DEPARTMENT.

It is true that comparatively little study of the kind herein recommended is done by ordnance officers. There is so much that they ought to know that their entire time could readily be devoted to study. The principal reason why they have not voluntarily devoted more time to study is to be found in the volume of work required of them and the relatively small number of officers to do it. Study can wait for opportunity, but the routine and other work must be done. The actual amount of work accomplished by the Department has been growing for a number of years in a continually increasing ratio. All of the arsenals are now insufficiently supplied with assistant officers and would be if all the vacancies in the Department were filled. When one officer is required to do the work of three or four in as many distinct departments he will necessarily slight them all.

For several years the writer has had charge, under general direction of the commanding officer, of four large departments at this arsenal, viz, shrapnel, fuses, primers, and chemical laboratory, and in addition a large part of his time has been necessarily spent on detached service. The result is that his desk and mind are filled with incomplete work. Some partially completed studies and calculations referring to shrapnel design have been laid aside for months; important matters in the fuse and primer departments have been taken up, only to be abandoned, because something else still more important required immediate attention; actual direction of the work in chemical laboratory has not been possible, and the officer here should not only direct, but participate in the work. Although nominally in charge of the laboratory for four years, the writer has not yet had time to take the full theoretical and practical course in the chemistry of powders herein recommended for student officers, and as his experience is not exceptional it follows that under present conditions ordnance officers at our arsenals can not be expected to seriously undertake time-consuming studies. The departments mentioned could fully employ four officers, and in trying to do the work of four men the writer realizes that he has not accomplished as much as one should accomplish under a proper adjustment of work and time.

This matter has a serious bearing upon the success of the proposed school.

Even if the students devote half their time to proving-ground work, as distinguished from school duties, we must assume that, in a class of ten, five are entirely withdrawn from regular department work. Instruction of these students can not be done properly if undertaken, as a side issue, by officers already overloaded with other duties. The president of the Ordnance Board and the commanding officer of the proving ground are natural selections for instructors, and yet it is known to the writer that they accomplish their present duties only by working night and day.

These facts are reported, not to advocate the inadvisability of establishing a school, but to show that the best results can not be obtained without increasing the number of officers in the Department.

If an officer detailed for ordnance duty proves inefficient, or if he is not returned to the Department promptly after his one year of line service (this service is now two years), all of his and the instructors' time consumed in teaching him will be lost, so far as furthering the work of the Department is concerned.

CONDITIONS LIMITING ORDNANCE INSTRUCTION.

If there were no such conditions, if the number of officers assigned to ordnance duty could be increased at will and instructed without limitations as to time and facilities, what changes would be advisable in the methods herein recommended?

Under these circumstances, a thorough course in both mechanical and electrical engineering should be given the West Point graduate after not more than one year's service in the line of the Army. He should be required to earn his degree in both branches at such a school as the Massachusetts Institute of Technology. He could probably do this in two years. It would not be advisable to establish a separate Government school for these branches, however. The number of students would be too small to secure economical use of the expensive equipment and staff of instructors that would be necessary, and any facilities for instruction inferior to those of a first-class school could not produce equally good results. As a general rule, his entire service as lieutenant and captain should be devoted to construction and designing, as distinguished from administrative work. His office should be in the machine shop or the laboratory. Each department of construction work should be under the direct charge of a competent officer who has made a specialty of that branch, and he should have at least one assistant in training to take his place.

After graduating at a technical school an officer should have short tours of duty at each arsenal and at the proving ground to familiarize him with all classes of ordnance work. During this time he would be taking, by correspondence or under the direction of the older officers at his station, the course herein recommended, omitting, of course, electrical and mechanical engineering.

If it were possible to concentrate the arsenal plants at one point this instruction would be much simplified and the expense and inconvenience of frequent changes of station avoided. Many other advantages still more pronounced would result.

Upon completion of his tour of the arsenals his specialty should be selected from his service record. He should then begin his training under the expert officer in charge of his specialty and with a view to succeeding him.

If required to serve with the line his service there should be as closely connected with his ordnance specialty as possible. It should be limited to that time during which the experience gained is increasing his value as a specialist in the Ordnance Department.

Assuming his age on graduation from West Point as 22, from a technical school as 25, on completion of his arsenal tours as 28 (six months each at the five arsenals of construction and the proving ground), and on promotion to his majority as 43, he will have had fifteen years' service in active construction and designing work, devoted principally to one specialty. These are the productive years of his life. As a major at 43 it is time for him to enter the administrative

department to fit himself for the general direction of work in all specialties for the responsibities of command.

No matter how capable a specialist he may have been as lieutenant and captain, it is now time for him to surrender his specialty to his successor and to devote his attention equally to all branches of department work with which he is connected. To assist him in this mental transformation or development his ordnance station should now be changed for the first time since his assignment to a specialty.

CONCLUSION.

The directions in the preceding letter of instructions from the Chief of Ordnance to submit "any recommendations of a general nature which your visits and study of the subject may suggest" have caused the writer to express freely his personal views on the general subject of ordnance education. The general impressions that he would convey may be summarized as follows:

1. Under the present system of "no instruction" and as a result of the system, ordnance officers are, as a rule, specialists without special education. Because a young line officer makes a satisfactory record in an examination which of necessity does not touch on important ordnance duties, he is officially declared competent to direct ordnance manufacturing work. Not only is no provision made for teaching him, but the conditions of his service are such that it is extremely difficult for him to make any progress in teaching himself.

2. The best way to improve these conditions is (1) to increase the Ordnance Department until each important subdivision of department work can be placed under the immediate charge of a competent specialist with an assistant officer in training to succeed him; (2) to thoroughly educate young officers in electrical and mechanical engineering at the best schools available; (3) to arrange their duties so as to give them time to complete their education as ordnance engineers, to systematize and direct their study to this end, and to provide for eliminating from the corps those who do not make satisfactory progress.

This plan assigns all engineering work of the Department, both practical and theoretical, to the officers, and removes the present necessity for depending upon civilian engineers.

As a general rule the departments of such works as Pratt & Whitney, Brown & Sharpe, etc., are under the direction of young, highly educated engineers, graduates of such schools as those visited. The same conditions are desired for the Government shops, with the addition of a closer bond between the engineer and the service.

This plan could not be adopted without material modification in the detail system of line officers for ordnance duty. The detail system for lieutenants is valuable in the facilities it offers for eliminating poor material, and a very limited service with the line would be beneficial to the ordnance expert.

As soon as this service ceases to improve him as an ordnance expert and begins to train him as a line officer it will become harmful through loss of time from his proper work.

3. Under existing conditions the above plan is not feasible, and the proposed course of instruction at the proving ground is the best that can be done to educate ordnance officers. It will not be possible to

secure the practical efficiency promised by the first plan, but the instruction given by this course will be very valuable, and will enable the officer, with the practical assistance which he can always obtain, to perform satisfactorily any duty that may be assigned him.

4. In any case, an increase of the working force of the Ordnance Department is necessary if more study is required, and the increase should be proportional to the study.

5. The estimated cost of extra machines and instruments for instruction in electrical and mechanical engineering and optics and for text-books and books of reference is—

For books	$650
For machines and instruments for course in engineering	2,500
For optical instruments and appliances	2,000

A suitable laboratory building should be supplied to receive this and other apparatus now at the proving ground. The equipment recommended is for a minimum, and the building should provide for its growth. The mechanical engineering laboratory recently completed for the Stevens Institute of Technology cost $65,000, and a similar building would not give more than the space needed for our combined equipments.

A plant for manufacturing smokeless powder on a small scale is not a necessary adjunct to the school, but it is necessary to complete the facilities of the powder laboratory, and it would cost about $50,000, as shown by Appendix D.

Very respectfully,

B. W. Dunn,
Captain, Ordnance Department, U. S. Army.

The Chief of Ordnance, U. S. Army,
Washington, D. C.

(Through Commanding Officer, Frankford Arsenal.)

[First indorsement.]

Frankford Arsenal, Pa.,
February 27, 1902.

Respectfully forwarded to the Chief of Ordnance, United States Army.

Appendix C to this report, giving list and cost of apparatus required for practical instruction in optics, will be forwarded upon receipt of information expected from the Warner & Swasey Co.

Frank Heath,
Major, Ordnance Department, U. S. Army, Commanding.

(37483—Enc. 1.)

Appendix A—*Text-books and books of reference.*

CHEMISTRY OF POWDERS AND HIGH EXPLOSIVES.

Author.	Subject.	Volumes.
Remsen	Introduction to Study of Chemistry	1
Meyer	Theoretical Chemistry	1
Sanford	Nitroexplosives	1
Cross & Bevan	Researches on Cellulose	1
Cooke	The New Chemistry	1
Eissler	Modern High Explosives	1

APPENDIX A.—*Text-books and books of reference*—Continued.

CHEMISTRY OF POWDERS AND HIGH EXPLOSIVES—Continued.

Author.	Subject.	Volume.
Guttman	Manufacture of Explosives	1
Berthelot	Explosives and Their Power	1
Gody	Traité des Matières Explosives	1
Berthelot	Essai de Mechanique Chimique	1
Chalon	Traité des Explosives Modernes	1
Bernadou	Smokeless Powders, Nitrocellulose, etc	1
Wisser	Explosive Materials	1
Do	Modern Gun Cotton	1
Walke	Lectures on Explosives	1
Munro	Index to Literature of Explosives	1
Lunge	Sulphuric Acid and Alkali	1
Wagner	Chemical Technology	1
Muspratt	Chemistry as Applied to the Arts and Manufactures	1
Cundill	Dictionary of Explosives	1
Watts	Dictionary of Chemistry	1
Thorpe	Dictionary of Applied Chemistry	1
Beilstein	Handbuch der Organeschen Chemie	1
	Total	23

MECHANICAL ENGINEERING.

Lanza	Friction	1
Do	Dynamics of Machines	1
Do	Mechanics of Engineering	1
Peabody	Thermodynamics	1
Do	Valve Gears, etc	1
Peabody & Miller	Steam Boiler	1
Peabody	Steam Engine Indicator	1
Do	Steam Tables	1
Sondericker	Notes on Graphic Statics	1
MacCord	Velocity of Diagrams	1
Poppelwell	Experimental Engineering	1
Thurston	Manual of the Steam Engine	1
Do	Friction and lost work in Machinery and Millwork	1
Shaw	Mechanical Integrators	1
Pochet	Steam Injectors	1
DuBois	Elementary Principles of Machines, Vols. I, II, and III	1
Do	Stresses in Strained Structures	1
Merriman	Mechanics of Material	1
Do	Treatise on Hydraulics	1
Ewings	Steam Engine	1
Low & Brevis	Manual of Machine Drawing and Design	1
Porter	Notes on Hydraulic Measurements	1
Frizell	Water Power	1
Blaine	Hydraulic Machinery	1
Scwamb and Merrill	Notes on Mechanism	1
Do	Notes on Gearing	1
Gill	Gas and Fuel Analyses	1
Holman	Precision of Measurements	1
Marshall	Elementary Machine Design	1
Tracy	Introductory Course in Mechanical Drawing	1
Lieckfeld	Practical Handbook on Gas Engines	1
Rose	Pattern Maker's Assistant	1
Do	Machine Shop Practice	1
Shelley	Workshop Appliances	1
Appleton	Encyclopedia of Applied Mechanics	1
Lockwood	Pattern Making	1
	Practical Iron Founding	1
Wylie	Iron and Steel Founding	1
Vosmaer	Mechanical and Other Properties of Iron and Steel	1
Newman	Notes on Concrete	1
Heminway	Indicator Practice and Steam Engine Economy	1
Compton & DeGroodt	Advanced Metal Work	1
Hasluck	Lathe Work	1
Do	Milling Machines and Processes	1
Brown & Sharpe	Universal Milling Machines	1
William Sellers	Machine Tools	1
Faunce	Mechanical Drawing	1
Unwin	The Elements of Machine Design, Parts I and II	1
Carpenter	Text-Book of Experimental Engineering	1
Kent	Mechanical Engineers' Pocket Book	1
Lockwood	Dictionary of Terms	1
Roper	Engineers' Handy Book	1
Church, Irving P	Mechanics and Engineering	1
Do	Notes and Examples in Mechanics	1
Jamieson	Text-Book on Applied Mechanics, 2 volumes	1

APPENDIX A.—*Text-books and books of reference*—Continued.

MECHANICAL ENGINEERING—Continued.

Author.	Subject.	Volume.
Perry	Applied Mechanics	1
Do	Calculus for Engineers	1
Todhunter	Mechanics for Beginners	1
Worthington	Dynamics of Rotation	1
Arnold	The Complete Cost Keeper	1
Unwin	Exercises in Woodwork	1
Jamieson	A Text-Book of Steam and Steam Engines	1
Brown & Sharpe	Formulas in Gearing	1
Spangler	Valve Gears	1
Barrus	Boiler Tests	1
Do	Engine Tests	1
Marks	Hydraulic Power Engineering	1
Grover	Modern Gas and Oil Engines	1
Herrmann	Graphical Statics of Mechanism	1
Fox & Thomas	Mechanical Drawing	1
Kennedy	Kinematics of Machinery	1
Goodman	Mechanics Applied to Engineering	1
Zahner	Transmission of Power by Compressed Air	1
Kerr	Power and Power Transmission	1
Flather	Dynamometers, and the Measurement of Power	1
Byrne	Inspection of the Materials and Workmanship Employed in Construction.	1
Fitzgerald	The Boston Machinist	1
Smith	Press Working of Metals	1
Do	Wire, its Uses and Manufacture	1
	Additional	34
	Total	113

ELECTRICAL ENGINEERING.

Author.	Subject.	Volume.
Thompson, S. P.	Dynamo Electric Machinery	1
Bell	Electric Transmission of Power	1
Steinmetz	Alternating Current Phenomena	1
Do	Theoretical Elements of Electrical Engineering	1
Fleming	Alternating Current Transformers	1
Thompson	Polyphase Electric Currents	1
Miller	Electric Telephone Practice	1
Carhardt & Patterson	Electrial Measurements	1
Kempe	Handbook of Electrical Measurements	1
Nicholls & Wallace	Laboratory Manual, Vol. II	1
Crocker	Electric Lighting	1
Sheldon	Dynamo Electric Machinery	1
Foster	Electrical Engineers' Pocketbook	1
Slingo & Brooker	Electrical Engineering	1
	Additional	1
	Total	15

OPTICS.

Author.	Subject.	Volume.
LeConte	Monocular and Binocular Vision	1
Parkinson	A Treatise on Optics	1
Zwick	Optical Experiments	1
Nolan	The Telescope, its Construction	1
	Additional	0
	Total	4

RECAPITULATION.

Chemistry of explosives	23
Mechanical engineering	113
Electrical engineering	15
Optics	4
Miscellaneous	35
Aggregate	190

At $5 per volume = (say) $950.

(37483—Enc. 2.)

APPENDIX B.—ELECTRICAL MACHINES AND INSTRUMENTS REQUIRED IN ADDITION TO THOSE NOW ON HAND AT THE PROVING GROUND.

A 2-phase composite wound alternator of 25 kilowatt capacity, with exciter.

A 3-phase rotary converter of about 5 kilowatt capacity, with pulley for driving as a double current generator and with a frequency from 40 to 60.

A 3-phase induction motor arranged with starting resistance of about 2½ horsepower.

A single phase induction motor of 1 horsepower capacity.

A pair of static transformers of about 5 kilowatt capacity arranged for transformation from 3-phase to 2-phase.

An A. C. switch board pannel with ammeters, voltmeter, circuit breakers, rheostat, and switches for controlling the generator output.

One Weston D. C. voltmeter, portable No. 4.

One Weston D. C. ammeter, portable No. 4.

One Weston A. C. voltmeter, portable No. 21.

One Weston A. C. wattmeter, portable No. 4a.

One multiplier for same, ratio 2:4.

One Thompson inclined coil A. C. ammeter, range zero–5, zero–25.

One slide wire bridge and accessories, including galvanometer and tripod base, battery key, 2 battery cells (P. and A.), extension coils.

One Wheatstone bridge and accessories, including Thompson plane mirror galvanometer, shunt box, bridge key, coils for measurement, telescope and scale.

Extra apparatus for plant tests, including scales and tanks for boiler tests; 2 indicators and accessories for engine tests; Mahler bomb outfit for fuel tests; string brake (modified Prony) for stray power tests of dynamos.

The following list shows the present equipment of the proving ground in electrical machines and instruments, plant, machines, etc.:

One storage battery with 65 accumulators for lighting purposes—125 ampere hours. Type 13 E. Nine E. M. F. cells, also 10 accumulators for velocity firings. Six portable accumulators for velocity firing with 5 cells each.

Four LeBoulengé Chronographs—Breger improvements—complete, with rheostats, disjunctor, line, switches and 2 Western Union switch boards.

One Squiers-Crehore polarizing photo chronograph.

One Schmidt chronograph.

One drop chronograph.

One Woodbridge chronograph with

One break circuit chronometer.

One Sebert velocimeter.

One self-registering projectile for Sebert velocimeter.

One old style generator and Thompson incandescent dynamo, volts 220, speed 1,170, class D30; 1 switch board, voltmeter, ammeter, overload and underload switch, field rheostat, and line switch.

Two direct-connected 25 kilowatt 250 volts C. and C. Electric Company generators, type M. P.

One switch board with 8 overload switches, 3 voltmeters and 2 ammeters and connections, line switches, and 2 rheostats.

Six 7½-horsepower motors, 112 volts, on Gantry crane.

One 1½-horsepower motor, 225 volts, on Gantry crane.

One Zeiss field glass, No. 8, with eyepiece tubes modified for the purpose of shortening the focal length, and they may now be focused on objects 6 feet away.

Seven dry-firing and night-sight batteries.

Twelve dry cells, good, in use.

One multiplier for Weston direct-reading voltmeter.

Eight telephones, installed.

Two telephones, portable.

Two annunciators.

One ammeter, portable.

One chloride of silver battery, dry, Barrett's, exhausted.

Twenty Le Clanché dry batteries.

Nine electric fans.

Cables, underground, lead covered: 800 feet, with No. 12 wire, 10 conductors; 185 feet, with No. 14 wire, 26 conductors; 830 feet, 22 wires; 1,557 feet, lead covered, number of wires unknown; 900 feet, lead covered, with 15 conductors.

Galvanometers: Two detectors for pocket; 1 tangent, Gangain, Helmholtz; 1 Universal, Siemens.

One Guardian register.

One rheostat, Queen's post-office box.
Four circuit breakers.
One telegraph instrument.
One voltmeter, portable.
One Brown & Sharpe vertical spindle milling attachment for No. 3 Brown & Sharpe Universal milling machine.
One Brown & Sharpe circular milling attachment for No. 3 Brown & Sharpe Universal milling machine.
One 14-inch by 28-foot traverse head shaper, complete, including counters with two speeds.
One 16-inch by 10-foot engine lathe, complete.
One 14-inch by 7-foot Gem lathe, Fitchburg Machine Works.
One center grinder, varying in swing from 14 to 24 inches.
One 60-inch full Universal radial drill, complete; countershaft to be equipped with friction pulleys for forward and backward motion.
One 13-inch Sensitive drill.
One Universal cutter grinder, complete, with all attachments.
One 72-inch vertical boring and turning mill.
One power shears with 10-inch blade; capacity for cutting 1¼-inch round and ⅜-inch plate.
One steam hammer, 16-inch stroke, capable of striking blow of 2,000 pounds, 200 blows per minute.
One 3-inch cutting-off machine; 2 speed countershaft.
One brass melting furnace, for forced draft; capacity 250 pounds.
Engine lathes: Two 16-inch, 4 feet between centers; 1 20-inch, 6 feet between centers; 1 24-inch, 11 feet between centers; 1 42-inch, 18 feet between centers; 1 24-inch, 18 feet between centers; 1 30-inch, 8 feet between centers; 1 Speed, 18-inch swing, 4 feet between centers; 1 24-inch, 8 feet between centers.
One 15-inch shaper.
One planer, 10-foot bed, take 30-inch square.
One 15-inch slotter.
One B. and S. miller, No. 3.
One P. and W. miller, No. 1.
One bolt-cutting power No. 3, Merriam; cuts up to 2-inch bolts.
One blower, Smith's.
One back-geared drill, 32-inch.
One portable drill, No. 3, Dallett's.
One drill radial, 4 by 4 feet.
One tool grinder.
One drill grinder with mill attached.
One steam engine, 42-horsepower, Strutter's.
One steam engine, 25-horsepower, Putnam's.

For the information of the officer to be assigned as instructor in mechanical and electrical engineering, the following letters, pamphlets, and blank forms are submitted [omitted from this report]:

Appendix B, Exhibit A: Letter from Prof. F. A. Laws, Massachusetts Institute of Technology, on course in electrical measurements for ordnance officers, with recommendations and estimates of cost of equipment, submitted in connection with

Appendix B, Exhibit B: Notes on electrical measurements for students of Massachusetts Institute of Technology.

Appendix B, Exhibit C: Letter from Mr. E. Chesrown, electrical engineer.

Appendix B, Exhibit D: Letter from Prof. Henry H. Norris, department of electrical engineering, Cornell University.

Appendix B, Exhibit E: List of electrical apparatus and estimate of cost, as recommended by Professor Hodges, Rensselaer Polytechnic School.

Appendix B, Exhibit F: Sample blank forms used at the Massachusetts Institute of Technology for recording data obtained in the practical work in the course of mechanical engineering.

Appendix B, Exhibit G: Bound volume of blank forms for recording data from practical tests in department of mechanical engineering at Stevens Institute of Technology.

Appendix B, Exhibit H: A set of blue prints and explanatory note illustrating and describing the shop work at Cornell University.

APPENDIX C.—OPTICAL APPARATUS.

One 1½-inch azimuth instrument (for range-finder work) for practice in assembling and adjusting.

One model 1898 gun sight for practice in assembling and adjusting.

One adjusting stand for setting optical axis of gun sight parallel with mechanical axis.

One stand for testing the cross level and vertical movement of gun sight, including fine striding level.

One level-testing instrument.

One standard 3-inch telescope on tripod, with eyepieces giving powers of 15, 25, and 35 (side of telescope to be removable to show the interior, and to have removable prism).

One 2-inch spyglass on tripod (Galilean type), three eyepieces.

One 2-inch Porro prism telescope, powers 10, 20, and 30.

One spherometer.

One special instrument for testing focal strength of objectives, same to be provided with colimator and eyepieces with cross wires.

One marine field glass (Galilean type), power 6.

One set of Porro prism field glasses in case, 6, 8, and 10 power.

One set of lenses of various forms.

One set eyepieces, including Ramsden, Huygen, and Airy.

Total cost for purchase, installation, and incidentals, $2,000.

(37483-13—Enc. 1.)

APPENDIX D.—ESTIMATE OF COST OF A SMALL PLANT TO MANUFACTURE SMOKELESS POWDER.

It is not desired to do this on a commercial scale, but the plant could be readily expanded for this purpose if necessary. A single type of each machine and building required in a large plant is provided. A very small plant would cost more, since the miniature machines would have to be specially designed and built. The following estimate was made by Lieutenant Williams, Ordnance Department:

Articles.	Cost.	Horse-power.
Acid tanks	$300	....
Nitrating centrifugal	900	20
Tubs, steaming and boiling	200	....
Pulper	1,400	35
Wringers (2)	2,000	10
Dehydrating press	1,700	....
Mixer	1,000	6
Macaroni press	1,900	....
Block press	1,300	....
Grain press	2,100	....
Pressure pump and lines	1,500	25
Intensifier and lines	1,500	....
Air compressor and lines	1,500	....
Total	17,300	96

BUILDINGS.

Building.	Cost.	Size.
1. Storage house, raw cotton, and other materials	$1,500	20 x 12 x 9
2. Raw cotton dry house, built on any of ordinary designs	2,000	20 x 12 x 9
3. Nitrating house (size depends upon whether centrifugal or pots be used)	1,500	....
4. Steaming house; 1 wringer, 1 tub	1,000	20 x 15 x 8
5. Pulping house; 1 pulper, 1 tub	1,500	20 x 15 x 9
6. Dehydrator house; 1 dehydrator	1,000	12 x 10 x 9
7. Mixer house; 1 mixer	1,000	12 x 10 x 9
8. Press house; mixing press, block press, grain press, and cutting table	2,000	20 x 12 x 9
9. Blending house	1,000	20 x 12 x 9
10. Power house	2,000	....
11. Boiler house	1,000	....
Total	15,500	....

The estimates for building include the foundations for machines which they will contain.

POWER PLANT.

Articles.	Cost.
1. Steam engine and lines	$10,000
2. Boiler and lines	
3. Generators and lines	
4. Motors	

SUMMARY.

Machinery, etc	$17,300
Buildings	15,500
Power	10,000
Water supply, preparation of grounds, installation, and incidentals	10,000
Grand total	52,800

All of the buildings estimated for above are to be either frame covered with tar paper, or wooden skeleton covered with sheet or corrugated iron.

This estimate is for the installation of one machine of minimum capacity for each of the essential steps in the process of manufacture.

(37483—Enc. 12.)

APPENDIX IV.

COMPETITIVE TEST OF FIELD ARTILLERY MATERIAL.

AUGUST 21, 1902.

SIR: The board respectfully submits report of tests of rapid-fire field material conducted, pursuant to your instructions of September 28, 1901, and December 5, 1901, under the programme prepared by the Board of Ordnance and Fortification.

1. The systems tested used fixed ammunition and comprised eight pieces, to be chiefly distinguished in three classes, as follows:

(1) Gun and carriage recoiling as a unit:
   - Armstrong 3-inch, rigid carriage with elastic axle spade, Clarke pattern. Screw brake on carriage.
   - Cockerill-Nordenfelt, 75 millimeter (2.953-inch), Belgian pattern. Nordenfelt breech mechanism. Wheel shoe recoil breakes. Gun in cradle with azimuth movement on carriage.

(2) Gun having short recoil on carriage, and 2 hydraulic cylinders inclosing counter recoil springs:
   - Ordnance Department No. 1, model 1900, 3-inch Gerdom breech mechanism. Gun in cradle, with 8 inches recoil, and azimuth movement on carriage. Trail spade, to be raised for traveling. Screw brake on carriage.
   - Vickers-Maxim, 75 millimeter (2.953-inch), gun in cradle, with 14.25 inches recoil, and azimuth movement on carriage. Fixed trail spade. Wheel shoes.

(3) Gun with long recoil on carriage:
   - Bethlehem No. 2, 3-inch Lewis carriage. One hydraulic and 2 hydropneumatic cylinders inclosing counter-recoil springs, with 40 inches recoil. Axle traverse for azimuth movement. Fixed trail spade. Wheel shoes.
   - Bethlehem No. 3, 3-inch. Two hydraulic cylinders, with 40 inches recoil. Counter-recoil springs in trail, with wire-rope retraction. Axle traverse for azimuth movement. Fixed trail spade. Wheel shoes.
   - Ehrhardt 3-inch, Norwegian pattern. Nordenfelt breech mechanism. Gun in cradle with 53 inches recoil, and azimuth movement on carriage. Single hydraulic cylinder enveloped by counter-recoil springs. Extension trail and fixed trail spade. Screw brake on carriage.
   - Ordnance Department No. 1, model 1901, 3-inch Gerdom breech mechanism. Gun in cradle with 46 inches recoil, and azimuth movement on carriage. Two hydraulic cylinders inclosing counter-recoil springs. Fixed trail spade. Lever brake on carriage.

2. All the pieces were furnished with limbers, except that but one limber was provided for the two Bethlehem pieces. Three of the limbers, namely, Bethlehem, Ordnance Department long recoil, and Vickers-Maxim, were fitted with springs supporting the ammunition chest.

3. All the material entered in the trials was purchased or manufactured for the Government except the Bethlehem No. 3, which was submitted by the Bethlehem Steel Company.

4. As the trials were intended primarily to test the efficiency of the carriages, combined with rapidity of fire, and the accuracy of the guns,

the programme provided for the use of blind-loaded projectiles only. Fused shell and shrapnel were, however, employed in the field trials. The ammunition, complete, used in each piece was procured from the manufacturers of the material, except shrapnel for the Bethlehem and Cockerill guns. No shrapnel were furnished for these pieces, and the shrapnel used with them were adapted from service projectiles by the rebanding as required for each piece. The projectiles furnished for the Armstrong, Cockerill, and Vickers-Maxim guns were designed for a weight of 14.33 instead of 15 pounds. The Armstrong and Cockerill projectiles were weighted for 15 pounds, as required, but in the case of the Vickers-Maxim it was found impracticable with the powder furnished to meet the ballistic requirements of the programme. It was therefore decided to test this material with the weight of projectile furnished and muzzle velocity, 1,640 feet per second, for which it was designed.

5. The Bethlehem Steel Company also sent to the proving ground a gun and carriage designated No. 1. This material embodied separate loading of the projectile and powder charge, short recoil of gun on carriage, and pneumatic action. This piece was, however, shortly withdrawn by the company and not subjected to trial.

6. The test of 3-inch B. L. rifle No. 1, model 1898, designed for separate loading, was concluded contemporaneously with the present trials. Report upon this gun was submitted under date of May 22, 1902. The conclusion was reached that as regards rapidity of aimed fire the rate of the separate loading gun is about one-half that of guns using fixed ammunition.

7. The trials were conducted under "Programme for test of field artillery," dated War Department, Board of Ordnance and Fortification, Washington, D. C., October 22, 1901, a copy of which is inclosed. Firings of the guns at the proving ground were commenced in October, 1901, and continued until April, 1902. The material was then sent to Fort Riley, Kans., where during four weeks it was subjected to field tests comprising marches and firings and a special practice march of 150 miles. After this it was returned to the proving ground and finally subjected to the tests for excessive charges and defective ammunition. The tests were completed in July, 1902.

8. When the trials were sufficiently extended to observe the performance of the material under the rapidity and accuracy tests and on various kinds of platforms, the conclusion was reached, as reported February 4, 1902, that the pieces having long recoil of gun on carriage were distinctly superior to the others by reason of their steadiness under fire and their ability to keep on the target without moving the carriage or resetting the trail for a considerable number of rounds. It was then proposed to discontinue the tests of the carriage systems at the proving ground except the four long recoil mounts, but to enter all in the practice march with the purpose of testing the different patterns of carriages and limbers and developing any features of special merit that some of them might possess. These views were concurred in by the Board of Ordnance and Fortification, and thereafter the general programme was continued only with the Bethlehem Nos. 2 and 3, the Ehrhardt, and the Ordnance Department long recoil systems, and only firings intended to test the breech mechanisms were executed at the proving ground with the Armstrong, Cockerill, Nordenfelt, Ordnance Department short recoil, and Vickers-Maxim material.

9. Further trials shortly developed very unsatisfactory results with

the Bethlehem No. 3 piece having wire-rope retraction. The trials were marked by irregular recoil and necessity for frequent adjustments of the hydraulic recoil valves. The jump was considerable and the piece could not be served by cannoneers seated on the trail. The counter recoil was relatively violent and sufficient at times to throw the carriage forward and pull the spade from its hold in the ground, and the system showed a general lack of the requisite steadiness under fire. The wire retraction cable parted twice. On the second breakage, and after the piece had been fired 209 rounds, it was decided to discontinue the tests of this system.

10. The material sent to Fort Riley, Kans., for the field tests comprised 7 of the 8 pieces (guns, carriages, and limbers) already enumerated, omitting the Bethlehem No. 3. A 3.2-inch field-gun equipment of service pattern was joined to the battery, which was commanded in the maneuvers by Capt. Granger Adams, Artillery Corps. Capt. George W. Burr, Ordnance Department, was present to observe and report upon behavior of the material

DESCRIPTION OF MATERIAL.

11. The accompanying table, entitled "Data concerning construction and test of experimental field-artillery material," gives full and complete data relating to dimensions and weights of the material and the general results of the trials. The principal features of the guns, gun carriages, and limbers are otherwise briefly described, as follows:

LIST OF DESCRIPTIVE PHOTOGRAPHS OF MATERIAL.

ARMSTRONG.

[Photographs 1, 2, 3, and 4.]

12. The gun is a built-up steel construction consisting of tube and jacket, the latter with solid formed trunnions.

13. The breech mechanism (photograph 1) is of the interrupted screw type, with 3 threaded and 3 slotted sectors. A slide seated in guides in a block carrier is so connected by a link to the operating lever, and by a crank to the breechblock, that a single movement of the lever to the right rotates the block until the threads are disengaged, and then swings it clear of the breech. The firing mechanism is of the continuous pull type.

14. The sights (I, photograph 34) are located on the left side of the gun, the rear sight so near the breech that the gun layer interferes with the rapid working of the breech mechanism. The rear sight is a straight bar tangent sight without clinometer or correction for difference of level of wheels.

15. The carriage (photograph 2) is an example of the type which has carriage recoil as distinguished from gun recoil. It consists of a short, stout trail of the usual flanged construction, terminating at its rear end in a shoe plate similar to that of the 3.2-inch service carriage, and at its forward end in trunnion beds which receive the trunnions of the gun. The elevating mechanism consists of the ordinary double screw. The piece has no azimuth movement on the carriage.

The recoil of the carriage is checked by a spade elastically connected to the axle and to the trail. A telescopic arm pivoted to a bracket at the middle of the axle carries at its lower end a corrugated steel sheet spade which is urged from the axle by springs placed in the arm. The spade is connected by stout wire cables to a spring column attached to the trail near its middle point. In recoil the carriage rides back over the spade until the pull on the wire cables draws the spade along the platform with the carriage. When the recoil is checked, the compression of the springs in the spade connections is sufficient to throw the carriage forward into approximately its original firing position. In traveling the spade is hooked up under the trail.

The carriage is fitted with road brakes and with axle seats for the cannoneers; the seats have back and foot rests.

16. The limber (photograph 4) consists of a light sheet-metal frame securely fastened to the axle. A stout pintle hook is riveted to the frame in rear, and a wooden pole is seated in and keyed to it in front. The singletrees are attached to the side rails of the frame.

The ammunition chest, built of wood, is fastened directly to the frame. The chest door opens downward to the rear, forming a table for the convenience of the ammunition servers. Inside, the chest is divided by wooden partitions into compartments to take 10 ammunition carriers, a wooden tool box, and 3 tin fuse boxes. The ammunition carrier has a light sheet-metal frame with 3 wooden diaphragms perforated to take 4 rounds of ammunition. Each chest carries 40 complete rounds of ammunition.

17. The ammunition furnished with the Armstrong carriage consists of cast-iron shell, common steel shell, and shrapnel. The shrapnel have a base charge and are fitted with a dial-set combination fuse.

The powder charge (cordite) is put up in a cartridge bag in the metallic cartridge case. The fixed ammunition as carried in the ammunition chest is fitted with a blank percussion primer. At the firing ground this is unscrewed and replaced by a live primer.

BETHLEHEM NO. 2.

[Photographs 5 to 9, inclusive.]

18. The gun is a built-up construction consisting of tube, jacket, and breech ring. The latter is screwed on under shrinkage and carries the recoil lugs and the carrier hinge lugs. The jacket has solid-formed ribs or feathers which guide the gun in recoil.

19. The breechblock (photograph 5) is conical, with interrupted involute collars. The plane of the collars is perpendicular to the axis of the block; their cross section is that of an inclined V thread with rounded tops and bottoms. The collars cover two-thirds of the surface of the block, there being two plane sectors of 60° each.

The operating lever is pivoted on the lower end of the carrier hinge pin. A single link connects the lever to the rear face of the block, the connection in each case being a ball and socket joint. A continuous motion of the lever rotates the block until the collars are disengaged from their seats, and then swings it clear of the piece.

The firing pin is cocked as the block is rotated in opening; it is held in this position during loading and closing of the block by the usual sear arrangement and is fired by a lanyard. A safety arrangement makes it impossible to pull the sear before the block is fully closed.

20. The carriage (photographs 6 and 7) consists of a trail, wheels and axle, and a cradle containing the recoil cylinders.

The cradle is mounted by trunnions in trunnion beds at the upper end of the trail. The latter is of the usual construction of two flanged flasks of sheet steel tied together by transoms. Its rear end terminates in a fixed spade and in a lunette of shape adapted to the special pintle on the limber. At its upper end a bronze box is bolted to its lower side, forming a bearing for the axle upon which the trail is moved in traversing the piece. The axle is curved, forming the arc of a circle of radius equal to the horizontal distance from axle to point of support of trail. The axle arms are screwed on the ends of the curved part and pinned to prevent unscrewing. The arms are turned to take the Archibald patent roller-bearing wheels. The curved portion of the axle is rectangular in cross section and has cut on its rear face a rack which meshes with the worm wheel of the traversing gear.

The power for traversing is transmitted from the crank handle at the left of the trail to the axle through a wheel and pinion, a pair of bevel wheels, and a worm and worm wheel.

The elevating gear consists of a triple screw mounted on a cross head journaled between the flasks. Power is applied to the middle screw by means of hand spokes. The head of the inner screw is attached by a yoke to the rear end of the cradle.

The cradle is a steel casting provided with trunnions, upon which it rests on the trail, with clips for the recoil guides of the piece and with three cylinders for the recoil system. These cylinders lie side by side under the piece.

The middle cylinder is 2 inches in interior diameter and contains a solid piston connected to a lug at the breech of the gun by a piston rod passing through a stuffing box at the rear end of the cylinder. The other two cylinders, each 2¾ inches in diameter, are connected at each end by ports with the middle cylinder. Each outer cylinder contains a double coiled spring, which bears in front against the cylinder head and in rear against a floating piston.

When the cylinders are properly filled with oil, an air space equal to one-half the volume of the middle cylinder is left in the portions of the cylinders in front of the pistons.

When the piece recoils the oil in the middle cylinder is driven through the ports at its rear end into the outer cylinders, driving back the floating pistons and compressing the springs. When the piece has recoiled far enough for the piston to drive one-half of the oil from the middle cylinder into the outer cylinders, a second throttling begins, due to oil being forced from the outer cylinders through the front ports into the inner one. The energy of recoil is absorbed by the throttling of the oil in its passage through the ports and by the springs. At the end of recoil the springs acting on the floating pistons drive the oil back through the rear ports into the middle cylinder, and thus return the gun to battery. To return the piece to battery, as well as to hold the piece in battery, at high angles of elevation, the oil in rear of the recoil piston head must be under pressure. To maintain this pressure a small pump is provided on one of the cylinders to pump oil from the space in front to that in rear of the pistons. To reduce leakage the piston heads are packed with a spring-cup packing.

No device is provided for checking the counter recoil of the piece.

Supplementary firing brakes in the shape of wedge-shaped wheel shoes are provided. They are attached by jointed arms to collars on the axle, and in firing are placed in rear of the wheels and are fastened by chains back to the end of the trail, so as to prevent the wheels from passing over them in recoil. For traveling the shoes are folded over on the axle and keyed in place.

21. The sights, front and rear (IV, photograph 34), are mounted on a bar which rests in bearings on the left side of the cradle. The rear sight is provided with a level for giving elevations and with one for correcting for difference in level of the wheels. It is graduated in degrees and minutes for both range and deflection.

22. The limber (photograph 9) submitted with the Bethlehem carriages comprises a metallic chest mounted upon springs on a running gear consisting of wheels, axle, hounds, and pole.

The wheels are of the Archibald patent roller-bearing type, and are arranged to be oiled through an oil hole without removing the wheels.

The axle is made of two hollow tubes connected by screw joints to a solid union. The latter is bored out and slotted to form the socket for the ball and socket joint of the pintle arrangement.

The hounds are formed of a piece of metal plate of channel cross section bent into a U shape. The axle pierces and is securely fastened to the arms of the U, and the portions of the arms in front of the axle are brought together to form the fork. The latter affords a seat for the metallic pole, which is keyed in place. The doubletrees are attached to a stud bolt at the front end of the fork.

The pintle arrangement consists in a rod pivoted to the middle of the axle by a ball and socket joint and terminates in rear, where it rests on the hounds, in a pintle stud and with semiautomatic lock. It is designed to unlock by hand, and to lock automatically when the lunette hole is placed over the pintle stud.

The footboards, resting upon brackets on the fork, afford a support for the road brake. The shoes bear against the front of the wheels. The brake is operated by a foot lever conveniently placed for use by a cannoneer seated on the limber chest.

The chest is made of sheet metal stiffened by angle irons. It is supported at each end by a stout elliptical spring securely clamped to the axle, and in front by a similar spring placed transversely on the fork.

Inside and extending lengthwise of the chest are three sheet metal diaphragms, each pierced with 44 flanged holes to take that number of rounds of ammunition. The chest door is lined with wood, covered with heavy felt, which bears against the heads of the cartridge cases. The door is hinged at the top, and when opened, is held by a spring catch to the back of the cannoneer's seat on top of the chest. Compartments are provided at one end of the chest for four oil cans and at the other end for a case containing tools and spare parts.

23. The ammunition furnished with Bethlehem material consisted of sand-filled shell. The shrapnel and fuses used in the tests were furnished by the Ordnance Department. The powder charge (Du Pont's nitroglycerin) was placed loose in the cartridge case.

BETHLEHEM NO. 3.

[Photographs 10 and 11.]

24. This carriage differs from the Bethlehem No. 2 carriage principally in the recoil and counter-recoil system. The gun, breech mechanism, trail, wheels, and axle, are similar in the two systems.

The elevating apparatus is the usual form of a double screw actuated through a train of gears by a crank placed on the left side of trail.

The piece recoils in a cradle which is mounted on trunnions in bearings at the front end of the trail. The recoil cylinders (two in number) are in the cradle under the gun. The piston rods pass through stuffing boxes at the rear end of the cylinders and are fastened to lugs on the breech ring of the piece. The pistons and rods are bored from the front to take the throttling rods which are fixed to the front heads of the cylinders. These rods are turned with cross-sections varied so as to give a constant resistance to recoil. The piston head is fitted with a rotating valve designed to control the counter recoil of the piece.

The counter-recoil springs are placed in the lower end of the trail. They consist of three parallel columns; the two outer ones are equal in strength to and work tandem with the middle column, so that the stroke of each column is approximately one-half of the recoil of the piece. Wire cables lead from the two outer columns around ball-bearing pulleys on the cradle trunnions and through covered grooves in the cradle to the breech of the piece to which they are attached.

25. The sights (VII, photograph 34) are mounted in sockets attached to the left side of the cradle. The front sight is an ordinary V point; the rear sight is a straight bar tangent sight, graduated in degrees and minutes, for both range and deflection. It is without levels of any kind.

COCKERILL-NORDENFELT.

[Photographs 12 to 15, inclusive.]

26. The gun is 2.953 inches in caliber and is a built-up construction consisting of tube, jacket, and key ring. The jacket has a single trunnion, on which the gun is mounted in the rocker and around which it has an azimuth motion of 3 degrees on each side of the axis of the carriage.

27. The breech mechanism (photograph 12) is of the Nordenfelt eccentric screw type, in which the block is opened or closed by being turned 180 degrees about its axis. The operating lever is secured to the breech face of the block by a bayonet joint. It carries the firing mechanism, which is of the continuous-pull type, the mechanism being cocked and the piece fired by a lanyard pulled from the rear. The extractor lies in the groove in the breech recess and has a lip at its front end engaging the rim of the cartridge case. It is actuated by a lug at its rear end working in a cam groove in the breechblock.

An automatic safety lock is provided, which is tripped at the discharge of the piece. At other times it must be tripped by hand before the breech can be opened.

28. The piece has no recoil upon the carriage (photograph 13). The recoil of the latter upon the ground is checked by wheel shoes elastically connected to the carriage. The carriage consists of a trail, wheels, axle, rocker, pointing mechanism, and firing brakes.

The trail consists of two flasks of the usual shape, and terminates at the lower end in a broad plate-metal shoe or float to keep it from sinking into the ground in firing. At the front end the trail is provided with trunnion beds to take the trunnions of the rocker on which the piece is mounted.

The rear end of the rocker rests on the double-screw elevating device. The rocker terminates in the arc of a circular rack, struck with the gun trunnion as a center. A worm mounted on a shaft attached to the under side of the breech of the piece meshes with the rack and gives the piece azimuth motion.

The axle is hollow, with separate axle arms shrunk in. The wheels are secured by linchpin and washer. They are self-oiling, spring-compression grease cups being located between the spokes of each wheel.

The firing brake consists of two wedge-shaped wheel shoes pivoted on the ends of a brake beam passing under the trail. At each end the beam is connected to eccentric collars on the axle. Belleville springs on the brake rod make this connection an elastic one. Brake chains are attached to the brake beam near the wheel shoes and extend back under the trail, to which they are fastened by means of a coiled spring.

In action the wheel shoes are pressed against the wheels by the eccentric axle connection, and their rotation about the axle is limited by the brake chains. The carriage moves back and up on the shoes when the piece is fired and is returned to the firing position by gravity, aided by the coiled spring in the trail connection of the brake.

For traveling the wheel shoes are raised from the ground until the brake beam comes in contact with the under side of the trail, where it is automatically secured by a spring catch. In this position the shoes are arranged to act as a road brake.

The carriage is fitted with axle seats for two cannoneers.

29. The sights (III, photograph 34) are mounted in sockets on the left side of the piece. The rear-sight arm is curved in the arc of a circle, the center of which is the front sight. It is graduated in degrees and in thousandths of the distance between the sights. The deflection scale is graduated in points corresponding to thousandths of the range. The sight is without a level for correcting for differences of level of wheels, but has a clinometer for determining the vertical angle of target and for elevations in indirect laying.

30. The limber (photograph 15) consists of a frame of angle irons, to which the limber chest is firmly riveted. A metallic pole is keyed in a seat in the frame in front, and a pintle hook swivels on an eye-piece riveted to it in the rear. The singletrees are fastened directly to the front part of the frame.

The limber chest and frame are supported by two cylindrical rubber buffers which rest on the axle. The frame is securely fastened to the axle by chain ties and by braces.

The chest is of sheet metal, stiffened by angle irons. The door opens to the rear downwards forming a shelf for the service of the ammunition. The chest is strengthened by three vertical partitions and is arranged to take ten ammunition carriers, each holding four rounds. These carriers are sheet-metal frames, with leather-lined bearings for the cartridges.

The top of the chest forms a seat for three cannoneers. It is provided with side rails and a high back.

31. The ammunition furnished with this material consisted of cast-iron shell, filled and fused, weighing 14.33 pounds each. For the tests these shell were emptied and then sand weighted to 15 pounds. The shrapnel used in the tests were made by the Ordnance Department. The powder charge (B. N. smokeless) was placed loose in the cartridge case.

EHRHARDT.

[Photographs 16 to 20, inclusive.]

32. The gun is made of nickel steel and consists of a tube over which is shrunk a jacket, secured longitudinally by means of a locking ring screwed to both parts. Over the tube are also shrunk two stout collars provided with clips, which hold the gun to and guide it on the sides of the cradle during recoil. The front collar reaches down into the cradle to take the front end of the hydraulic cylinder. The rear end of the jacket forming the breech recess is screw threaded.

33. The breech mechanism (photograph 16) is of the "Nordenfelt" or eccentric screw type. The block is cylindrical, of a diameter about double that of the base of the cartridge case, and is screw threaded. An opening for loading is cut through from front to rear and to one side of the axis of the block. It is screwed into the breech recess and fits in such a way that, when in the loading position, the cut away portion leaves the chamber clear for the introduction of the cartridge, and when revolved about its axis about 180 degrees to the firing position the solid part of the block closes the chamber. The solid part of the block is bored out axially to receive the firing pin. The operating lever is attached to the breech face of the block by a bayonet joint. A continuous-pull firing mechanism is assembled with the operating lever. Cocking and firing is executed by pulling to the rear on a firing lanyard or by actuating the firing lever. The latter is attached to the left side of the cradle and is convenient for use by the gun layer.

The extractor slides in a groove in the right side of the breech recess. A lip at its front end engages the rim of the cartridge and a lug at its rear end, working in a cam groove on the block, gives the extractor longitudinal motion as the block is rotated.

Safety devices prevent the breech from opening accidentally, also firing before the breech is properly closed. The firing mechanism can be locked when traveling with a loaded gun.

34. The carriage (photograph 17) consists of the cradle, with recoil system, the trail, wheels, and axle, and pointing mechanisms.

The cradle is made of steel tubing of U-shaped section, is open at the top, forming slides on which the clips of the gun move during recoil. It is closed at the front by a steel plate riveted on and at the rear by a movable plate secured by a bayonet joint.

Inside the cradle is the hydraulic cylinder surrounded by the counter-recoil springs. The cylinder recoils with the gun. Its front end is attached to the projecting collar near the muzzle of the gun, and its rear end rests in and slides through the rear-end plate of the cradle. The springs bear against the collar in front and this plate in rear. The springs are helical and are coiled from round steel bars. They are assembled on the cylinder in five sections of four concentric coils each, with separator plates between the sections.

The piston is solid. The rod passes through a stuffing box at the front end of the cylinder and is pinned to brackets at the front of the cradle. Four grooves of uniform depth but varying width are cut in the walls of the cylinder and permit the passage of the liquid from one side of the piston to the other during recoil. They are so proportioned that they afford a constant resistance to recoil at all times.

The return of the piece to battery is eased by a counter-recoil buffer formed by the end of the piston rod fitting into a female buffer on the rear head of the cylinder.

The cradle is pivoted to the axle and can thus be traversed to right or left.

The trail consists of two seamless steel tubes sliding into one another. The length of this telescoping motion is 32.25 inches. The front tube is connected to the axle by a yoke in such manner as to have a motion about the axle as an axis; the rear tube terminates in a lunette and trail spade.

The double-screw elevating device is pivoted to the left side of the front tube and supports at its upper end a table upon which the rear end of the cradle slides in azimuth. The azimuth motion is given by a traversing worm shaft actuated by a handwheel. The elevating screw is worked through bevel gears by a handwheel.

Fastened to the trail are seats for the use of the gunner and the member serving the breech mechanism. Two axle seats for cannoneers are provided, also a road brake actuated by a handwheel from the axle seat.

The axle is hollow and forged in a single piece.

The wheels are made entirely of steel, and consist of a nave of compressed steel, spokes of weldless steel tubing, two fellies of steel tubing, and a steel tire.

35. The supports for the front and rear sights (V, photograph 34) are attached to the left side of the cradle. The front sight is a V-point protected by a ring shield and carried on a hinged support, which allows it to be swung against the cradle for traveling. The rear sight, known as the Korrodi sight, consists of a bar constituting the arc of a circle, the center of which is the point of the front sight. It is inclined in its socket at an angle to the plane of symmetry of the piece to allow for drift. The bar has at the top a crosshead carrying a deflection leaf on which is the sighting notch. A clinometer level is provided. The sight bar is graduated in degrees and sixteenths, the deflection scale in points equivalent to one one-thousandth of the range.

36. The limber (photograph 19) consists of a metal frame directly connected to the hollow steel axle. The side and middle rails are prolonged to the front, where they are connected by a splinter bar and covered by a perforated sheet-metal plate for a foot rest. The singletrees are attached to the splinter bar. A wooden pole is keyed in a seat at the front of the middle rail; at the rear a stout pintle hook is securely fastened. The wheels are of wood, but are of the same size and interchangeable with those of the carriage.

The chest is secured directly to the frame. It is of sheet metal and is divided into compartments by one horizontal and four vertical partitions. Each compartment takes a wicker basket holding four rounds of ammunition. Each round is protected during transportation by a woven mantlet or cover. Habitually nine baskets or thirty-six rounds of ammunition are carried in the chest, the tenth compartment being filled by a box containing lubricants, small tools, and spare parts.

The limber chest door opens downward to the rear, forming an ammunition table. On top of the chest is a cannoneer's seat, fitted with high side and back rests.

37. The ammunition furnished with the Ehrhardt material consists of cast-iron shell, with point fuse and base charge shrapnel, with dial-set combination fuse. The powder charge of Troisdorf nitrocellulose powder in tubular form is put into the case in a bundle, over the rear end of which is slipped a bag containing the black-powder igniter.

ORDNANCE DEPARTMENT, SHORT RECOIL.

[Photographs 21 to 24, inclusive.]

38. The gun is a built-up rifle consisting of tube, jacket, locking ring, recoil band, and breech mechanism. The jacket envelops the rear end of the tube and is held in place by a locking ring shrunk over the front part of the jacket and an annular projection on the tube. The recoil band, shrunk over the rear end of the jacket, is provided with carrier-hinge lugs and piston-rod lugs. Four longitudinal feathers on the jacket and front end of the locking ring fit in grooves in the cradle and guide the gun in recoil.

39. The Gerdom breech mechanism (photograph 21) for metallic ammunition is used. The block is interrupted screw threaded, with two plane and two threaded sectors, the plane sectors being flatted. It is screwed into the block carrier by a thread of the same pitch as the threads of the block. Bevel gear teeth on the rear face of the block mesh into corresponding teeth on the operating lever, which is pivoted on the carrier just under the block. The carrier is hinged on the right side of the breech. A continuous motion of the operating lever rotates the block until its threads are disengaged, and then swings it clear of the breech.

The block is bored out axially to receive the firing mechanism. The latter is a continuous-pull mechanism; the firing pin is cocked and the piece fired by a quick pull of the lanyard.

The extractor has a ring lip, which encircles the rim of the cartridge case; it also has guides which run in longitudinal grooves in the breech recess. The extractor lever is pivoted near the carrier hinge, and is so shaped that it acts first as a wedge to start the empty case from its seat and then as a lever to throw it clear of the breech.

40. The carriage (photograph 22) consists of the cradle, yoke, trail, wheels and axle, and pointing mechanism.

The cradle has four grooves, which receive the feathers of the gun. On the underside of the cradle are the two recoil cylinders, which have solid pistons with rods passing through stuffing boxes at the rear to the recoil lugs of the gun. Throttling in the cylinders is effected by cutting in each cylinder three grooves of uniform width, but of depth varied so as to make the resistance caused by the passage of the liquid through them plus the resistance of the springs constant at all points. The counter recoil is effected by helical springs bearing against the pistons and the rear ends of the cylinders. To soften the shock of the return to battery, counter-recoil buffers are formed at the front ends of the cylinders.

The cradle has trunnions at its front end, which rest in trunnion beds in the yoke. The latter rests on and is clipped over circular flanges on the front transom, forming a turntable for traversing. An arm of the yoke projects to the rear and is connected to the traversing screw, which gives an azimuth movement of 4° on each side of the axis of the carriage. The elevating mechanism is of the usual double-screw type. The elevating and traversing crank handles are conveniently located at the left side of the trail.

The trail is the usual construction of flanged steel. The trail spade is arranged so as to be folded up under the trail when not in use.

The axle is hollow, of forged steel, in one piece, and is passed through and keyed to the flasks and to the front transom. The wheels are a modified form of the Archibald type, 56 inches in diameter. There are no linchpins. The outer end of the nave is steel capped. An interrupted collar is fitted on the axle, and a similar collar is cut in the inner end of the nave. The wheel is put on the axle and turned so that these interruptions slip over each other; the axle collar is then locked to the wheel by a sliding bolt and turns with it. The nave is practically dust proof, and is oiled through oil holes without removing the wheels.

The carriage is fitted with axle seats and road brakes.

41. The front and rear sights (II, photograph 24) are attached to brackets bolted to the cradle. The front sight is a bead protected by a ring. The rear sight consists of a curved arm fitting into a curved socket in the rear bracket, and having a slide at its upper end. The centers of curvature of the arm and of the guides on which the slide moves is the front sight. The curved arm is graduated for elevation in degrees and minutes; the deflection scale of the slide is graduated in 3-minute points, very nearly one one-thousandth of the range. The peep sight is placed in a socket on the slide; when desired it may be removed and a telescopic sight substituted. Either sight is left on the piece in firing. The sight is provided with a clinometer level and a cross level.

42. The limber (photograph 24) consists of the chest, middle and side rails, wheels, axle, and pole.

The chest, of sheet steel, is strengthened by three continuous T bars passing around it from end to end. Inside three diaphragm plates extend lengthwise of the chest and support 40 seamless drawn tubes, whose interior dimensions conform to those of the gun chamber. The door of the chest opens downward to the rear, forming a table for the service of the ammunition. The door closes to contact with the primer shields, and thus holds the flanges of the cartridges against the ends of the tubes.

The chest is supported by and riveted to the two side rails of the frame. These rails project to the front, for the attachment of the footboards. On top, the seat with high back extends over each side of the chest, to provide room for three men.

The middle rail is made of two pieces of plate of semicircular section passing above and below, and riveted to lugs on the axle. It is securely braced to the axle. The ends of the middle rail are brought together in front, to form a clamp seat for the metallic pole and in rear to afford a point of attachment for the pintle. The latter is given a swiveling motion about its longitudinal axis, to prevent twisting of the trail on uneven ground. The pole seat is provided on top with a stud bolt for attaching the doubletrees.

The wheels and oiling arrangements are the same as those on the carriage.

43. The ammunition used with this piece is the same as that used with the Ordnance Department long-recoil carriage.

ORDNANCE DEPARTMENT LONG RECOIL.

[Photographs 25 to 29, inclusive.]

44. The gun is a nickel-steel built-up gun, consisting of tube and jacket. The tube is enveloped for a distance of 40 inches from its rear end by a jacket. In front of the jacket the tube is cylindrical, 6 inches in diameter. Two feathers, each 17.5 inches long, are formed on the tube just in front of the jacket. In recoil they run in grooves in the cradle and serve as guides for the gun.

45. The Gerdom breech mechanism (photograph 25) for fixed ammunition is used. The block is of the interrupted-screw type, with two threaded and two flatted sectors. In rear of the interrupted-screw part the block is cylindrical, of reduced diameter, and has a continuous thread of same pitch as that of the interrupted screw. This continuous thread fits into the carrier as a nut. The block is bored out to receive the firing pin and mechanism. Bevel-gear teeth are formed on its rear face and mesh with those on the operating lever. The latter is pivoted on the carrier immediately under the block. The rear end of the block is closed by a steel cover. In rotating the block in opening the breech a cocking lever draws the point of the firing pin below the face of the block, where it is caught by the sear. In rotating the block to close the breech this lever compresses the mainspring. The mechanism is provided with a positive safety device, which makes it impossible to fire the piece before the breech is fully closed. The firing mechanism lies in the axial hole in the block.

The gun may be fired by a lanyard attached to the sear catch, but habitually it is fired by a lanyard attached to a lanyard catch on the cradle. This catch is in a bearing underneath the right side of the cradle, and has a square hole in the middle, in which the connection rod works. The latter is a square shaft with a bearing in the right recoil lug on the jacket. At the rear end of the rod is a bent lever, which works in a slot in the sear catch.

The extractor has a ring which passes entirely around the rim of the cartridge and guides which slide in grooves in the right side of the breech recess. The extractor lever is proportioned so as to act first as a wedge to start the empty case from its seat and then as a lever to throw it clear of the breech.

46. The carriage proper (photographs 26 and 27) consists of the following principal parts: Cradle, rocker, flasks and transoms, axle wheels, spade, traversing and elevating mechanisms, and sights.

The cradle receives the gun and controls it in recoil. It has the general form of a cylinder with the upper part cut away, leaving two bands, one in front and one in rear. Slots in each side of the cradle for its entire length guide the feathers of the gun in recoil. When the piece is in the extreme recoiled position, about 12 inches of the feathers bear in the slots of the cradle in the rear, and the front band of the cradle bears on the chase of the gun in front.

Three bands are cast on each side with their centers 2.5 inches below that of the cradle. These bands receive the recoil cylinders, the middle ones being threaded for this purpose. The cylinders are assembled from the front and screwed up to a shoulder in the middle band.

The recoil cylinders are made of drawn steel tubing and are about 64 inches long and 4 inches in interior diameter. Each cylinder is fitted with a steel piston and rod in one piece. The rod passes through a stuffing box at the rear end of the cylinder and is attached to a recoil lug on the breech of the piece. Three longitudinal grooves cut in the walls of the cylinders form orifices through which the liquid can pass from one side of the pistons to the other. The depth of these grooves along the cylinders is calculated to make the resistance which the liquid offers to the passage of the pistons, plus the resistance of the springs, such that the carriage will have no jump when the piece is fired at 0 degrees elevation. This object is accomplished and at the same time the recoil is made as short as possible by making at each instant the moment of the weights of the system around the axle through the point of support of the trail a maximum limit for the amount of the pull of the piston rods about the same axis.

For returning the piece to battery each cylinder is provided with a coiled ribbon spring made in 3 sections and placed on the piston rod between the piston head and the rear cylinder head. The initial tension of the spring is adjusted to return the piece to battery when fired at an elevation of 15 degrees.

The front end of each cylinder is closed with a cylinder head capped over the end and screwed on. A bronze rod screwed into this cylinder head fits with small clearance into a hole bored into the piston head and rod from the front. When the springs return the piece to the firing position after recoil, the liquid caught in this hole by the rod can only escape by this small clearance, thus checking the velocity of the gun and easing its return into battery.

The underside of the cradle is provided with clips and guides which fit over corresponding parts on the rocker. The cradle and rocker fit together in such a way as to allow the cradle a motion in azimuth of 4 degrees on each side of the center line of the carriage. The clips which hold the cradle to the rocker are interrupted, and, by turning the cradle 45 degrees around a vertical axis, it becomes disengaged from the rocker.

The traversing of the cradle with respect to the rocker is effected by turning a handwheel whose shaft has its bearing in the rocker. A worm on this shaft actuates a rack bolted to the cradle. The rocker is a steel casting and has its front bearing on the axle, around which it rotates when the gun is elevated. It is supported in rear by the elevating screw.

The flasks are of forged steel, each flask being in the shape of a channel. For attachment to the axle there are riveted to the front ends of the flasks cast-steel axle bearings. These bearings are split in front and are clamped on the axle by bolts and nuts The axle is hollow and is made of forged steel in a single piece.

The lunette ring and spade is made in one piece of cast steel and riveted to the flask. A peculiarity of the spade consists in the wings which spread out 5 inches on either side of the blade and prevent excessive burying in the ground.

The elevating mechanism consists of a double screw, a bevel pinion and bevel gear, the latter actuated by a balanced crank on the left side of the trail. The mechanism is mounted in journaled bearings between the flasks, and in the traveling position is securely housed by the flasks and transoms.

The wheels are a modified form of the Archibald pattern, 48 inches in diameter, with dust-proof nave boxes, and are arranged to be oiled through automatic closing oil holes without removing the wheels. The method of fastening the wheels on the axle is given in the description of the Ordnance Department short-recoil carriage.

The road brakes are worked by hand lever so placed as to be operated from the ground or from the axle seat. The brake shoes are in front (rear of piece limbered) of the wheels, so as to be put out of the way of the cannoneers serving the piece.

The axle seats have wheel guards and high backs and are spring mounted. Underneath each seat provision is made for carrying two rounds of ammunition (shrapnel), so as to have four rounds at hand for instant use in emergencies.

Two seats are provided on the trail for use of the gunner and the member who operates the mechanism.

47. The front and rear sights (II, photograph 34) are attached to brackets bolted to the left side of the cradle. They are conveniently placed so that the gunner seated on the trail seat with his eye at the sight can reach the elevating and traversing handwheels. The sights are described in the description of the Ordnance Department short-recoil material.

48. The limber (photograph 29) comprises a running gear supporting on elliptical springs an ammunition chest. The middle rail is made of two pieces of plate of semicircular section passing above and below and riveted to lugs on the axle. It is stayed sideways by tie-rods. Both front and rear ends of the rail are closed together, the former to form a clamp seat for the metallic pole and the latter to form a support for the pintle. The pintle has a swiveling motion about a longitudinal axis. The doubletrees are attached to a stud bolt at the front of the middle rail.

The chest is made of sheet steel and is strengthened by three continuous T-bars passing around it from end to end. Two side rails of channel section are riveted to it and project to the front for the attachment of the footboards.

The elliptical springs which support the chest are securely clamped on the axle and are connected at each end to the side rails.

Inside, the chest is provided with angle-iron guides at the top and bottom for guiding ten ammunition carriers, which slide into it from the rear. Each carrier consists of a steel frame containing four brass tubes conforming in interior dimensions to the chamber of the gun.

The chest door opens downward to the rear, forming a table for the use of the ammunition servers.

On top the seat is extended over the ends of the chest to give room for three cannoneers. It is fitted with a high back rest. In front, on the footboards, provision is made for carrying four oil cans and a lantern.

The axle is hollow and forged in a single piece. The wheels and oiling arrangements are the same as on the carriage.

49. The ammunition used with this piece consisted of cast-iron shell with base fuze and base charge shrapnel, with Frankford Arsenal combination fuze. All projectiles weighed 15 pounds. The powder charge (Du Pont's nitrocellulose) was put up in a cartridge bag in the cartridge case.

VICKERS-MAXIM.

[Photographs 30 to 33, inclusive.]

50. The gun is a built-up steel rifle of 2.953 inches caliber and consists of a tube over which is shrunk a jacket secured longitudinally by interlocking. In front of the jacket a short hoop is shrunk on the tube.

51. The breech mechanism (photograph 30) is of the single-movement, interrupted-screw type, with two threaded and two flatted sectors. The block is slightly conical, large end to the front.

The operating lever is pivoted on the carrier and is provided with a bevel pinion which engages in a toothed segment on the rear face of the block. A horizontal movement of the lever rotates the block until the threads are disengaged and then swings it clear of the breech.

The firing mechanism lies in an axial recess in the block. Two cams in this recess engage studs on the firing pin and force it into the cocked position as the block is rotated for opening. It is held in the cocked position by means of a sear. To fire the piece it is necessary to trip the sear by pulling a lanyard. In case of a missfire the piece can be recocked without opening the breech.

The extractor is of the lever variety, with two lips which engage the cartridge rim at opposite extremities of the diameter. It is pivoted near the carrier hinge and is actuated in the usual manner.

52. The carriage (photograph 31) consists of the cradle and hydraulic cylinders, pointing mechanism, trail, wheels, axle.

The piece rests in the cradle, which is provided with two cylinders, one on each side. The rear ends of the cylinders are closed by stuffing-boxes through which the piston rods pass to the recoil lugs on the breech of the gun. The counter-recoil springs are placed on the rods in cylinders. The length of recoil is 14 inches.

The cradle rests on a semicircular platform, to which it is held by clips. This platform is the center of the traversing movement of the system. The lower part of the platform forms a bearing for the horizontal shaft around which the system pivots vertically. This shaft is supported in brackets riveted on the trail.

At the rear end of the platform is a toothed segment gearing with a worm in bearings on the cradle, thus providing for the azimuth movement. The double-screw elevating device is attached to the platform immediately below the toothed segment. The elevating screw is actuated by hand and gear wheels supported on brackets in the trail. The elevating and traversing handles are conveniently placed for use by the gunner.

The trail is the usual built-up construction, fitted at the lower end with a broad shoe to prevent digging down into the ground, and with a shallow spade to assist in checking the carriage recoil. The axle is cranked and fixed to brackets bolted to the sides of the trail.

At each end of the axle are eye collars to which are connected the firing brakes. For traveling they are hung on the sides of the trail; for firing they are placed on the wheels, where their eccentric connection gives a powerful braking effect. There are no road brakes, but, if required on the road, one or both of the firing brakes may be used to lock a wheel.

Two axle seats for the foot and back rests and arm guards are provided.

53. The sights (VI, photograph 34) are fitted in supports on the left-hand side of the cradle and do not recoil with the gun. The foresight is a point, the rear sight an open notch. The rear sight consists of a straight bar sliding in a socket inclined to the plane of symmetry of the piece to allow for drift. The deflection bar is graduated to read to ten minutes. The sight bar is graduated for range in yards. There are no levels provided with the sights.

54. The limber (photograph 33) consists of an ammunition chest secured to a frame which is attached by means of springs to an axle.

The chest is made of steel plate and is divided by a horizontal and four vertical partitions into ten compartments, each holding an ammunition carrier. On top of the chest is a seat for three men, with arm and back rests; at the rear is a door opening downward to a horizontal position and which is held closed by sliding bolts at the upper corners.

The ammunition carrier is made of four brass tubes held together by a steel frame. The interior of each tube is made to duplicate the chamber of the gun. The carrier is fitted with a hinged lid lined with felt.

The limber frame is made of steel angles, and consists of middle and side rails, tied together by front and rear rails. The limber chest is securely fastened on the rear part of the frame; the portion in front of the chest is covered by footboards. The front rail projects beyond the frame to the right and left, and its ends are braced back to the side rails and fitted with footsteps to facilitate mounting. This rail serves as a splinter bar, having hooks for the attachment of singletrees, and trace eyes for use without singletrees.

The middle rail is provided in front with brackets for the attachment of the pole. The latter is of wood and is keyed in place. The pintle hook is securely riveted to the middle rail at its rear end.

The side rails are each provided with two stout brackets reaching down to the ends of elliptical springs, which are secured by clamps to the axle.

The axle is a rectangular bar terminating in axle arms. The wheels are of wood and are secured on the axle by linchpins and washers.

55. The ammunition furnished with this material consists of cast-iron shell with point fuse, base charge shrapnel with dial set combination fuses, and case shot. The powder charge of ballistite is put up in a bag in the cartridge case.

PROVING GROUND TRIALS.

56. Firing records complete, including those of the field test and the separate target plates have been previously forwarded to your office.

They contain full details of the tests and will form a part of this report. The material was inspected and subjected to a series of firings and other tests at the proving ground, as called for by the programme, as follows:

57. During the inspection the time required to perform the operation of dismounting the piece and to replace certain parts, etc., was taken, as given in the following table:

Time of maneuvering.

Operation.	Armstrong.	Bethlehem No. 2.	Bethlehem No. 3.	Cockerill-Nordenfelt.	Ehrhardt.	Ordnance Department short recoil.	Ordnance Department long recoil.	Vickers-Maxim.	Remarks.
	M. s.	*M. s.*	*M. s.*	*M. s.*	*M. s.*	*M. s.*	*M. s.*	*M. s.*	
To dismount the piece.	3 45	3 0	6 0	28 0	22 30	1 5	3 7	4 0	Piece placed on skids near carriage by 8 men.
To mount the piece	3 .0	3 0	6 15	28 0	20 0	3 0	3 30	6 0	Piece handled by 8 men.
To take breech mechanism off of piece.	15	40	40	38	21	5.5	6	30	Armstrong required 1 tool; Bethlehem and Vickers-Maxim 2 tools for this operation.
To attach mechanism to piece.	21.5	1 52	1 52	42.5	37	18	18	22	Tools required as for preceding operation.
To replace broken firing pin or mainspring.	28	7 53	7 53	26	18.5	30	1 33	1 14	Vickers-Maxim requires 2 tools; Bethlehem 3 tools for this operation.
To dismount block from piece and carrier.	5 30	1 5	1 5	38	26.5	26	58	42	Armstrong, Bethlehem, and Vickers-Maxim each require 2 tools for this operation.
To mount block in carrier and on piece.	5 30	1 25	1 25	42.5	37	40	2 6	3 5	Tools required as for preceding operation.
To empty cylinders	......	......	......	......	5 5	......	2 56	3 15	No means provided for emptying Bethlehem and Ordnance Department short recoil cylinders.
To fill cylinders	......	10 16	......	......	5 35	7 50	6 50	2 25	Bethlehem No. 2 filled but not pumped up.
Time required to traverse piece from extreme right to extreme left position and return:									
With wheels on level ground.	......	60	53	5.4	12	8.4	30.2	4	Considerable lost motion in Bethlehem traversing gear.
Left wheel 6 inches higher than right.	......	69.2	83	5.4	12	12.8	31.4	6	
Time required to move piece from extreme depression to extreme elevation and back to first position:									
With wheels on level ground.	12.8	66.2	24.3	20	59	20.4	18.8	22	
With left wheel 6 inches higher than right.	12.8	66.2	24.3	20	59	21.4	18.8	25	

58. The standard velocity called for is 1,700–1,750 feet per second, with projectile weighing 15 pounds and pressure not to exceed 33,000 pounds per square inch. The next table gives the results of firings

made to establish the standard charges and for verification, at different periods, with ammunition in normal condition. All the projectiles were weighted to standard except the Vickers-Maxim. The B. N. powder furnished with the Cockerill gun and the ballistite furnished with the Vickers-Maxim gun gave irregular results in these tests. The same charge of Du Pont's nitrocellulose powder in the Ordnance Department long-recoil gun gave a velocity of 1,728 feet per second in March and 1,754 feet per second in July, 1902, showing an increase of 25 feet per second, to be attributed to difference in temperature. The Troisdorf nitrocellulose powder gave about the same increase of velocity under similar conditions.

Standard velocity and pressure.

System.	Date.	Number of rounds.	Weight of powder charge.	Weight of projectile.	Initial velocity.	Pressure.	Remarks.
			Ounces.	*Pounds.*	*Feet per second.*	*Pounds per sq. in.*	
Armstrong	Nov. 2, 1901	7	17.5	14.125	1,736	29,533	Projectiles used as received with gun.
	Nov. 8, 1901	5	18.5	15	1,722	32,260	Projectiles sand weighted.
	Jan. 2, 1902	3	18.5	15	1,729	....	
	.....do.......	2	25	15	1,745	27,800	Ordnance Department powder and shell used.
Bethlehem No. 2.	Nov. 4, 1901	6	19.94	15.125	1,810	32,840	Ammunition used as furnished with gun. Results very irregular.
	Nov. 7, 1901	4	19.125	15	1,724	31,310	Reloaded ammunition.
	Jan. 28, 1902	3	19.18	15	1,686	....	Charge increased in future to 19.375 ounces.
	Apr. 18, 1902	2	19.375	15	1,738	....	
Bethlehem No. 3.	Nov. 4, 1901	5	20.125	15.06	1,826	31,850	Ammunition used as furnished. Results irregular.
	Nov. 8, 1901	3	19.125	15	1,714	....	Reloaded ammunition.
	Nov. 9, 1901	3	19.19	15	1,733	30,960	
	Feb. 5, 1902	10	19.375	15	1,740	....	
Cockerill-Nordenfelt	Nov. 9, 1901	8	25.44	15	1,727	30,720	
	Jan. 2, 1902	5	25.44	15	1,725	....	Accurately loaded ammunition. Velocities very irregular.
	Mar. 28, 1902	5	25.25	14.33	1,747	31,360	Filled and fused shell. Charges for field tests fixed at 25 ounces.
Ehrhardt..	Nov. 1, 1901	15	25.875	14.33	1,738	27,910	Results very irregular.
	Nov. 6, 1901	3	26.125	15	1,727	29,380	Sand-weighted shell.
	Apr. 2, 1902	6	26.125	15	1,738	30,380	
	July 16, 1902	5	26.19	15	1,774	31,600	Part of ammunition used in field tests.
Ordnance Department short recoil.	Nov. 6, 1901	4	26.125	15	1,762	32,020	Charge reduced in future to 25.75 ounces.
	Dec. 4, 1901	4	25.75	15	1,762	31,325	Charge reduced in future to 25.125 ounces.
Ordnance Department long recoil.	Nov. 6, 1901	4	25.75	15.13	1,742	31,330	
	Dec. 5, 1901	3	25.75	15	1,764	31,300	Charge reduced in future to 25.25 ounces.
	Dec. 14, 1901	4	25.25	15	1,738	....	
	Mar. 1, 1902	3	25.125	15	1,728	....	
	July 16, 1902	5	25.125	15	1,754	33,760	Part of ammunition used in field tests.
Vickers-Maxim.	Nov. 12, 1901	5	18.25	15	1,645	33,900	Carriage is designed for 1,640 feet per second, with 14.33-pound projectile.
	Dec. 4, 1901	7	18.25	14.33	1,628	30,880	
	Jan. 2, 1902	5	18.25	14.33	1,681	....	Velocities irregular.
	Mar. 28, 1902	5	16.8	14.33	1,556	29,250	Used as received with gun. Same as used in field tests at Fort Riley.

59. The firings for accuracy with deliberate aim are summarized in the next table. The Armstrong gun gave erratic results with sighting shots, and this test was not resumed owing to breakage in the mechanism. Some of the best targets in this series were made with the short-recoil piece, notably the Cockerill and Ordnance Department guns.

Accuracy—Deliberate fire.

[Range, 2,500 yards. Vertical target, 30 by 40 feet.]

System.	Date.	Target.				Deviation from center of impact.			Remarks.
		Number sighting shots.	Direct hits.	Ricochet hits.	Misses.	Mean vertical.	Mean horizontal.	Mean.	
Armstrong	Dec. 31, 1901	10	...	...	...	...	...	...	Shooting erratic, on account of irregularity of ammunition.
Bethlehem No. 2	Dec. 6, 1901	8	10	0	0	6.48	3.70	7.46	
	Dec. 27, 1901	4	10	0	0	5.63	3.66	6.72	
	Jan. 10, 1902	3	10	0	0	7.93	5.17	9.47	
Bethlehem No. 3	Dec. 6, 1901	3	10	0	0	3.89	3.95	5.54	Elevation given by quadrant.
	Dec. 23, 1901	3	9	0	1	4.475	4.08	6.08	Deviations figured for direct hits only. Elevation by sight
	Dec. 27, 1901	2	9	0	1	4.76	3.76	6.06	
	...do...	2	10	0	0	4.76	3.95	6.19	
Cockerill-Nordenfelt.	Dec. 5, 1901	10	5	0	0	4.16	4.16	5.88	Target of 5 rounds only.
	Dec. 17, 1901	4	5	4	1	4	4.44	5.98	Deviations figured for direct hits only. Erratic shooting, due to irregularity of velocities.
	Dec. 31, 1901	2	5	2	3	3.64	2.76	4.57	
	Jan. 7, 1902	1	9	0	1	2.87	2.47	3.79	
Ehrhardt	Dec. 12, 1901	5	9	0	1	3.09	3.44	4.62	Deviations figured for direct hits only.
	Dec. 20, 1901	1	10	0	0	2.855	2.85	4.03	
	Jan. 9, 1902	5	10	0	0	3.15	2.67	4.13	
Ordnance Department short recoil.	Dec. 16. 1901	5	10	0	0	3.10	1.97	3.67	
	Dec. 28, 1901	3	10	0	0	4.95	3.77	6.22	
	Jan. 11, 1902	0	10	0	0	3.83	2.82	4.76	
Ordnance Department long recoil.	Dec. 11, 1901	5	8	0	2	...	...	...	Target rejected on account of change in sight reading during firing.
	...do...	4	8	2	0	3.59	3.57	5.06	Deviations figured for direct hits only.
	Dec. 21, 1901	3	10	0	0	2.57	7.36	7.79	
	Dec. 26, 1901	4	10	0	0	2.54	2.47	3.54	
Vickers-Maxim	Dec. 14, 1901	5	7	0	3	5.99	3.54	6.96	Deviations figured for direct hits only.
	Dec. 24, 1901	4	8	0	2	3.65	2.75	4.57	
		1	9	0	1	6.83	2.94	7.43	

60. The tests of 10 rounds for greatest rapidity of fire with each piece are summarized in the next table. The Armstrong gun failed in the breech mechanism. The two Bethlehem guns showed defects in the rapidity trials both in the breech mechanism and carriage systems. The Ehrhardt gun gave trouble from jamming the cartridge due to a burr caused by striking the band in loading. The same defect was shown in the Ordnance Department long-recoil gun, caused by the projectile band striking the inner edge of the tube which had been left a sharp corner at the mouth of the chamber. After this occurred the corner was slightly rounded and further difficulty was obviated. The failure of the automatic firing mechanism caused suspension of the first trial made with the Ordnance Department short-recoil gun. The greatest rapidity of fire was obtained with the Ordnance Department long-recoil gun, at the rate of 19.3 rounds per minute.

Rapidity unaimed fire.

[10 rounds—trail having been set by one shot.]

System.	Date.	No. of trial.	No. of rounds fired.	Time.	Rate per minute.	Remarks.
				Secs.		
Armstrong	Jan. 6, 1902	1	1	3	....	Firing mechanism jammed.
		2	1	4	....	Do.
		3	4	24	....	Firing pin and mainspring broken by blowback.
Bethlehem No. 2	Jan. 3, 1902	1	8	24	....	Sear caught at ninth round, jamming mechanism.
	Jan. 10, 1902	2	2	5.5	....	Cartridge jammed at third round.
		3	1	2	....	Right cylinder leaked.
		4	1	2	....	Cartridge jammed at second round.
		5	10	56.5	10.6	During test sticking of sear delayed opening of block. Link of mechanism cracked.
	Jan. 28, 1902	6	10	35.4	16.9	Best record with this piece.
Bethlehem No. 3	Jan. 3, 1902	1	8	15	....	Piece remained 6 inches out of battery.
		2	3	13	....	Link of breech mechanism broken.
	Jan. 10, 1902	3	5	20.5	....	Cannoneer operating mechanism slipped and fell.
		4	7	21	....	Handle of operating lever broken.
		5	10	35.5	16.9	Casing torn from spring column during test.
Cockerill-Nordenfelt.	Jan. 3, 1902	1	10	60	10	
Ehrhardt	Jan. 9, 1902	1	1	3	....	Stopped test to instruct cannoneers.
		2	9	55	....	Cannoneer operating mechanism too deliberate—another substituted.
		3	10	47	12.8	
	Jan. 15, 1902	4	1	4	....	Second round failed to fire because block was not entirely closed.
		5	6	27	....	Cartridge jammed on account of burr on projectile band.
		6	10	42.6	14.1	
Ordnance Department short recoil.	Jan. 3, 1902	1	3	10	....	Fourth round failed to fire—trigger not engaging sear.
		2	10	41	14.6	
	Mar. 20, 1902	3	10	32	18.75	This firing was done in the rust test of the mechanism.
Ordnance Department long recoil.	Jan. 3, 1902	1	10	50	12	Cannoneers interfered with each other.
		2	9	39	....	Cartridge jammed at tenth round, due to projectile coming out of case in loading.
	Jan. 9, 1902	3	10	33.5	17.9	
	Mar. 11, 1902	4	10	31	19.3	Fired in test of trail rigidly supported by oak post.
Vickers-Maxim	Jan. 3, 1902	1	10	40	15	

61. The tests of 20 rounds for rapidity with accuracy from both clay and rock platforms are summarized in the next table. Plate 1 shows all the targets in this series grouped on one sheet. The Armstrong gun was not included in this test. The wire retraction cable of the Bethlehem No. 3 was broken and terminated the tests of this carriage. The conclusion to suspend tests of the carriage recoil and short gun recoil systems was reached before any of these types, except the Cockerill, was tried on the rock platform. The Cockerill system performed well on the clay platform, generally returning for each discharge nearly to the firing position, but, in consequence of the recoil of carriage, the rate of fire was relatively slow. The Vickers-Maxim and Ordnance Department short-recoil systems showed the lack of steadiness inherent in this type of construction. On rock platform the departure from line of fire of the Cockerill gun was generally excessive. The Ehrhardt and Ordnance Department long-recoil systems only gave satisfactory performance. Both platforms considered, their accuracy was about equal, but the Ordnance Department gun was fired with greater rapidity.

Rapidity with accuracy.

[10 shell and 10 shrapnel at 30 by 39 feet vertical target, 2,500 yards distant.]

CLAY PLATFORM.

System.	Date.	No. of trial.	No. of round.	Time.	Rate per minute.	Target. Direct hits.	Target. Ricochet hits.	Misses.	Deviations from center of impact—for direct hits only. Mean vertical.	Mean horizontal.	Mean.	Remarks.
	1902.			*Secs.*					*Feet.*	*Feet.*	*Feet.*	
Bethlehem No. 2	Jan. 27	1	20	259	4.65	12	7	1	8.225	6.038	10.2	Considerable leakage of oil from cylinders.
Bethlehem No. 3	Feb. 27	1	1									Piece remained 8.25 inches out of battery; left wire cable broken.
Cockerill-Nordenfelt	Jan. 18	1	20	285.5	4.2	16	2	2	5.93	2.16	6.31	Departure from line of fire not excessive; piece easily trained.
Ehrhardt	Jan. 15	1	20	167.5	7.16	14	4	2	3.421	3.326	4.771	
Ordnance Department short recoil.	Jan. 23	1	7	69		5	0	2				Trigger bent and jammed in its recess, stopping test.
	Jan. 24	2	1	3								Trigger jammed again.
		2	20	300	4	12	4	4	6.416	7.16	9.61	Spade 18 inches in ground at end of test, causing excessive jump of wheels.
Ordnance Department long recoil.	Feb. 7	1	20	107	11.2	12	4	4	6.71	6.21	9.14	Setting of sight for shrapnel was incorrect, causing large proportion of misses.
Vickers-Maxim	Jan. 16	1	20	297	4.04	12	4	4	6.462	6.739	9.33	Considerable recoil of carriage and jump of wheels, causing departure from line of fire.

ROCK PLATFORM.

System.	Date.	No. of trial.	No. of round.	Time.	Rate per minute.	Direct hits.	Ricochet hits.	Misses.	Mean vertical.	Mean horizontal.	Mean.	Remarks.
Bethlehem No. 4	Apr. 16	1	20	792	1.51	13	5	2	6.653	3.961	7.743	Handle of operating lever broken. At 13 rounds trail was shifted or carriage moved on platform by hand. Carriage recoiled about 60 feet on platform. Traversing of piece on carriage very difficult. Lower edge and corners of trail spade bent.
Cockerill-Nordenfelt	Jan. 25	1	20	530.5	2.26	9	1	10	5.236	5.425	7.53	Misses due principally to incorrect sight setting for shrapnel. Departure from line of fire generally excessive.
Ehrhardt	Feb. 10	1	20	201	5.27	18	0	2	5.848	7.54	9.54	Point and lower corner of spade bent. Trail shifted for last few rounds.
Ordnance Department long recoil.	Mar. 3	1	20	135	8.89	19	1	0	3.93	3.018	4.95	Lower corners of spade bent. In 20 rounds piece moved 15 minutes in azimuth.

62. The tests of 45 rounds for maintained rapidity with accuracy are summarized in the next table. Plate II shows all the targets of this series grouped on one sheet. The Bethlehem No. 2, Ehrhardt, and Ordnance Department long-recoil systems only were subjected to this test. There is again in this case little difference between the accuracy of the Ehrhardt and Ordnance Department long-recoil guns, but the fire of the latter was considerably the more rapid, the time being 294 seconds, as compared to 399; the rate of the Ordnance Department gun is 9 rounds per minute for the 45 rounds, which included two changes of target.

Maintained rapidity with accuracy.

[Conditons: 15 rounds at 1,000 yards target No. 1; then 15 rounds at 2,500 yards target No. 2; then 15 rounds at 1,000 yards target No. 3; trail shifted in changing targets; clay platform. Targets Nos. 1 and 3, 25 by 40 feet: No. 2, 30 by 40 feet.]

System.	Date.	Target.	Number of rounds.	Time.	Rate per minute.	Target.			Deviations from center of impact, direct hits only.			Best 10 rounds of series.		Remarks.
						Direct hits.	Ricochet hits.	Misses.	Mean vertical.	Mean horizontal.	Mean.	Time.	Rate per minute.	
	1902.			Secs.					Feet.	Feet.	Feet.	Secs.		
Bethlehem No. 2	Apr. 18	1	15	387	2.33	15	0	0	1.951	2.062	2.839	238.5	2.51	Spade failed to catch in platform for first 23 rounds and carriage recoiled a total of 183 feet. Spade then caught in hole in platform and was left there for rest of firing.
		2	15	380	2.37	8	3	4	6.851	6.476	9.42	224.5	2.67	
		3	15	307	2.93	15	0	0	4.075	1.933	4.51	186	3.22	
Total			45	1,074	2.59	38	3	4						
Ehrhardt	Mar. 7	1	15	100	9	15	0	0	1.36	2.06	2.47	60	10	Recoil carriage on ground in 45 rounds, 9 feet 2 inches. At 6 rounds block closed with difficulty, due to cartridge binding in chamber.
		2	15	154	5.84	12	1	2	3.56	5.56	6.60	68	8.82	
		3	15	145.5	6.19	15	0	0	1.86	1.82	2.6	73.5	8.2	
Total			45	399.5	6.76	42	1	2						
Ordnance Department long recoil.	Mar. 4	1	15	70	12.9	15	0	0	2.57	1.44	2.94	46	13	Misses on No. 2 target due to fact that gunners neglected to change sight deflection in shifting to this target. All misses were close to right edge of target.
		2	15	107.5	8.36	6	0	9	6.68	3.208	7.411	47.5	12.6	
		3	15	116.5	7.72	15	0	0	2.02	1.76	2.76	42	14.3	
Total			45	294	9.2	36	0	9						

GENERAL TESTS OF CARRIAGE SYSTEM.

63. The general tests of carriage system comprised 225 rounds fired from each, the Bethlehem No. 2, Ehrhardt, and Ordnance Department long-recoil guns, from 5 kinds of platforms, namely, clay, loam, sand, rock, and macadam. On each platform there were fired 15 rounds at extreme elevation, 15 at zero, and 15 at extreme depression; 5 rounds in each series of 15 were fired with the piece in its extreme position right, 5 rounds in mean position, and 5 extreme left. In these tests the elevation, jump, and lateral movement of the wheels, departure of the piece from line of fire, depth of trail spade, recoil of piece on carriage, and of carriage on ground were carefully noted.

LOAM AND CLAY PLATFORMS.

64. The action of the carriages on the earth platforms being in most respects similar, for the sake of brevity the tests on these platforms will be considered together.

The Ehrhardt carriage was fired at maximum elevation with short trail; at other elevations, with extended trail.

65. *Action of spade.*—The spade of the Bethlehem No. 2 carriage failed repeatedly to take hold in the platform, permitting an excessive recoil of the carriage on the ground, and reducing in consequence the recoil of the piece on the carriage. At times in order to obtain comparative data this spade was placed in a trench prepared for it in the platform. The spades of the other two carriages generally caught in the platform at the first of each series of 5 rounds, and held there for the remaining 4 rounds.

66. *Depth of spade.*—The wings on the Ordnance Department spade bearing on top of the ground when the blade had attained a depth of about 5 inches, prevented it from sinking farther. The trail of the Ehrhardt performed in some measure a like office for its spade, so that its depth at the end of 5 rounds was usually about 7½ inches. The Bethlehem spade, as above stated, was slow to take hold; on hard ground it usually buried itself but little, and sometimes would scoop its way out of a hole made at the preceding round. On soft ground, when once the spade was well set, its tendency seemed to be to bury deeper than either of the others.

67. *Jump of wheels.*—At maximum elevation and at zero degrees the Ordnance Department carriage wheels did not jump from the ground; at maximum depression the wheels jumped less than 1 inch. At the former elevations the Ehrhardt wheels showed a slight tendency to jump; at maximum depression the jump averaged about 3 inches. With the spade holding, at maximum elevation the Bethlehem wheels had a noticeable jump; at zero degrees the jump was about 4 inches, and at maximum depression this was increased to 6 or 7 inches.

It should be noted here that the maximum depression of the Ehrhardt (with extended trail) is about 11 degrees, exceeding that of the Ordnance Department piece by 4 degrees, and that of the Bethlehem 5 degrees.

68. *Lateral movement of wheels and departure from line of fire.*—As would be expected from the nature of the traversing arrangements on the Bethlehem carriage, the lateral movement of the wheels was not great; it was, however, quite irregular, and this, in connection with

the tendency of the carriage to counter recoil to the front and pull the trail spade from its hole in the platform, frequently resulted in considerable departure from the line of fire. This departure from line of fire was noted with the piece in mean as well as in the extreme azimuth positions, and exceeded that noted below for the other carriages.

The lateral movement of the Ehrhardt wheels, with the piece in its extreme azimuth positions, averaged at maximum elevation 1½ inches per round, at zero elevation 2 inches, and at extreme depression 5 to 6 inches. For the Ordnance Department carriage these figures were ¾, 1¼, and 2¾ inches, respectively. In the mean azimuth position the side movement of these two carriages was practically zero. The departure from line of fire for the Ordnance Department and Ehrhardt pieces, when in extreme azimuth positions, varied about as the side movement of the wheels, that of the Ehrhardt being relatively somewhat less on account of the greater length of trail. At zero elevations this departure was usually from 30 to 40 minutes, the Ordnance Department piece averaging less than the Ehrhardt. The mean azimuth position, the departure from line of fire for both carriages, was very much less, and frequently was zero.

69. *Recoil and counter recoil of gun on carriage.*—The recoil on carriage of the Bethlehem piece was very irregular, varying from 19⅝ to 39½ inches. Its average recoil at zero degrees elevation was about 30 inches. The recoil of the Ehrhardt and Ordnance Department pieces was quite regular; the former averaged 50 inches for maximum elevation, 48 inches for zero elevation, and 45 inches for maximum depression. For the Ordnance Department gun these figures were 42.7, 41.2, and 40 inches, respectively. The counter-recoil action of the Ehrhardt and Ordnance Department pieces was quite uniform; the pieces returned to battery without shock. In all the tests on these two platforms there were but two occasions when the Ehrhardt, and one when the Ordnance Department pieces did not return fully to battery. Oiling the sliding parts and slightly releasing the stuffing-box gland remedied the trouble for the Ehrhardt and simply releasing the glands removed the difficulty for the Ordnance Department gun.

The Bethlehem piece habitually failed to return to its proper firing position. The cylinder would be pumped up so as to start firing with the piece fully in battery. As the firing progressed, the piece would fail to return to battery by an increasing distance and would be fired from its out of battery position as long as it was considered advisable to do so. Inasmuch as the carriage was designed for a permissible gun recoil of 40 inches and the recoil actually obtained averaged about 30 inches, it was considered that there was danger of the piston striking against the rear head of cylinder when the piece was fired from a position of more than 8 inches out of battery. When that distance was reached the firing would be stopped and the cylinders pumped up until the piece again returned fully into battery. Firing would then be resumed and continued until it was again necessary to pump up. This "pumping-up" process required a variable time; when the pump worked well two minutes was sufficient, but when the pump was not working properly, which was generally the case, the time required would run into hours rather than minutes.

It finally became necessary to pump up so frequently that the manufacturers asked permission to put in stronger counter-recoil springs,

thinking that would remedy the failure to return to battery. Authority was granted and the test of the carriage was suspended from February 20 to April 14, 1902, while the new springs were being procured and assembled. They were, however, without effect as far as insuring a full return to battery was concerned and the test was continued with this feature in the same unsatisfactory condition.

The failure to return to battery is undoubtedly due to leakages of oil from the rear parts of the cylinders past the pistons to the front parts, and also to leakages through the stuffing box and around the rear heads of cylinders.

Due to lack of a counter-recoil checking device, the piece frequently at maximum depression and zero elevation brought up with violence against the stops on the cradle and then rebounded a short distance from battery.

In this connection it is important to note that in this system the position of the piece in the cradle is an exceedingly unreliable index as to whether or not it is in a condition to be fired. The momentum of counter recoil may carry the piece, especially at low elevations, practically to its proper firing position and at the same time the amount of oil in the middle cylinder in rear of the piston may be less than necessary to prevent the piston from striking the cylinder head in recoil. During the tests the piece was frequently shoved from battery by hand in order to get a correct indication of the conditions existing in the cylinder. Moreover when this was not done and the amount of liquid in the middle cylinder was somewhat reduced, the piece at the beginning had free recoil and acquired considerable velocity before the piston brought up against the resistance of the liquid column. It is quite evident that such a state of affairs is not conducive to the stability of the carriage in firing.

70. *Recoil and counter recoil of carriage on ground.*—As indicated above, the recoil of the carriage on the ground depends very much on the action of the spade. The Ehrhardt and Ordnance Department spades habitually caught in the ground at the first round and thereafter the recoil on the ground did not exceed a few inches, varying somewhat with the hardness of the platform. The Ehrhardt, having the larger spade surface, showed slightly less movement than the Ordnance Department carriage. The Bethlehem carriage showed much more movement and much irregularity due to the failure of the spade to take hold properly.

The wheel shoes were not tried in the series of general tests on these platforms. They had been tried with this carriage on this platform in preliminary rounds for other tests and did not work well. When the spade caught in the platform they were unnecessary. When it failed to catch they reduced the recoil on the ground somewhat, but were in many ways a source of trouble. They require time to adjust; the shoes come off the wheels and the chains unhook from the shoes in firing, necessitating frequent readjustments; they contribute materially to the counter recoil of the carriage on the ground and generally increase very much the departure from line of fire.

The Ehrhardt and Ordnance Department carriages showed little or no counter recoil of the carriage upon the ground. Whatever movement there was was much reduced by the road brakes which were habitually set during firing. The Bethlehem carriage showed considerable counter recoil of carriage on ground and is provided with no

means of checking the movement. The counter recoil of gun on carriage at times is excessive and has a tendency to lift the trail spade from its hole in the platform, thus helping along the forward movement of the carriage.

71. *Leakage of cylinders.*—The Ehrhardt and Ordnance Department cylinders did not leak. Aside from the adjustment of the glands of the stuffing boxes no work of any kind was done on these cylinders.

The Bethlehem cylinders frequently leaked more or less through the stuffing box and around the rear heads of the cylinders. The lead washers under these heads gave way several times and had to be replaced. The tightening of cylinder heads and filling and pumping up cylinders to replace leakages were a frequently recurring cause of delay.

SAND PLATFORM.

72. On this platform the spades of all the carriages were buried to a considerable depth at the end of each series of 5 rounds. For the Bethlehem spade this depth averaged 16 inches at maximum elevation, 18 inches at zero elevation, and 19 inches at maximum depression. For the Ehrhardt spade these distances were 16, 15, and 18.5 inches, and for the Ordnance Department spade 12, 13, and 14 inches, respectively.

73. At maximum depression a rise or jump of the wheels was shown by the Bethlehem and Ehrhardt carriages, but not by the Ordnance Department carriage. At other elevations the wheels did not jump.

Before firing the first round of each series the wheels of the different carriages were usually embedded in the sand from 3 to 4 inches. In firing 5 rounds the wheels generally worked a little deeper, and in most cases the depth was about 5.5 inches and in no case exceeded 7 inches.

The lateral movement of the wheels per round of the Bethlehem carriage averaged at maximum elevation 1 inch, at zero elevation 1.5 inches, at maximum depression 1.5 inches. For extreme azimuth positions the corresponding distances for the Ehrhardt were 0, 1, and 2.5 inches, and for the Ordnance Department long recoil 0.75, 1.25, and 1.25 inches, respectively. For mean azimuth positions the Ehrhardt and Ordnance Department carriages showed no side movement.

74. The departure from line of fire per round for the Bethlehem averaged at maximum, zero, and minimum elevations 34, 63, and 81 minutes, respectively. For extreme azimuth positions these values for the Ehrhardt were 0, 24, and 70 minutes, respectively, and for the Ordnance Department carriage about 30 minutes each. For mean azimuth positions and all elevations the departure of the Ehrhardt and Ordnance Department pieces was very slight.

75. The length of recoil of gun on carriage and the action of the piece and carriage at counter recoil for the different carriages on this platform were practically the same as heretofore for the earth platforms.

The first 3 rounds from the Ehrhardt piece were fired at maximum elevation with short trail. The piece remained about 8 inches out of battery at each round. Examination showed that the end of the cylinder in recoil touched the sand heap thrown up by the trail spade and that the sand adhering to the cylinder prevented the complete return of the piece to battery. The cylinder was wiped off and the piece

thereafter was fired on this platform with extended trail without any further difficulty.

The Ordnance Department piece remained 2 inches out of battery at 3 rounds, but moved fully in when the stuffing-box gland was slightly released.

The difficulties with the counter recoil of the Bethlehem piece experienced on the earth platforms were repeated on this one. For the 45 rounds the cylinders were pumped up three times and filled twice. The cup packing on the recoil piston was renewed and the stuffing box repacked.

76. On account of the yielding nature of the platform the carriages had some movement to the rear at each round. For the Ehrhardt carriage this averaged 5 inches per round; for the Ordnance Department, 6¼ inches; and for the Bethlehem, 20 inches. None of the carriages had any counter recoil upon the platform.

77. During the firing of the Bethlehem piece a blow back bent the firing pin and upset the housing so that repairs were necessary before firing could be resumed.

78. In the progress of this test the Ehrhardt cylinder was dismounted for examination. It was gripped in a vise while the cylinder head was being unscrewed and afterwards was found to be considerably flatted at the point where it was held in the vise. The flatting was such that the spring separators would not slip over the cylinder. The difficulty was corrected by squeezing and filing the cylinder back into shape.

ROCK PLATFORM.

79. This platform, shown in photograph 20, is exceedingly rough, being formed by irregular pieces of granite of varying size placed closely together and the interstices filled with concrete. As there was little or no chance for the spades to dig into the platform, an attempt was made in all firings upon it to place the carriages so as to get suitable positions for the wheels and especially a good support for the trail against a projecting ledge or corner of rock. With the trail thus rigidly supported these firings constituted a severe test of the stability and endurance of the carriage.

The Ehrhardt piece was fired 7 rounds at maximum elevation with short trail; for the remainder of the firings the extended trail was used.

80. The jump of the wheels of the Bethlehem carriage at maximum elevation averaged 0.75 inch; at zero elevation, 7 inches; at minimum elevation, 9 inches; for the Ordnance Department carriage these figures were 0, 0.75 inch, and 2 inches, respectively. With extended trail at maximum elevation the Ehrhardt wheels did not jump, while with shortened trail the jump was 1.25 inches. At zero elevation it was 0.5 inch and at minimum elevation 3.5 inches, both with lengthened trail.

The lateral movement of the wheels of the Bethlehem carriage at maximum elevation was very slight; at zero elevation it was 2 inches; at maximum depression no measurements could be taken on account of the excessive counter recoil of the carriage on the rough platform. For the Ehrhardt piece, in extreme azimuth positions, the lateral movement at maximum elevation was 0; at zero elevation, 1.4 inches; and at maximum depression, 5 inches. For the Ordnance Department carriage these figures were 0, 1, and 3.4 inches, respectively. In

mean azimuth position, the lateral movement of the Ehrhardt and Ordnance Department carriages was practically zero.

81. The departure from line of fire of all the pieces on the rock platform was relatively about the same as on the earth platforms, but was much more irregular, due probably to the rigidity of the platform and the elasticity of the carriages. At maximum depression the Bethlehem piece was generally thrown far off of line of fire by the excessive counter recoil of the carriage on the ground.

82. The recoil of the Bethlehem gun on its carriage was quite regular and averaged 27.5 inches; the recoil of the Ehrhardt gun varied from 45 to 48 inches, and of the Ordnance Department gun from 41 to 42.5 inches, depending on the elevation.

The Ehrhardt and Ordnance Department pieces returned fully to battery after each round; in this respect the Bethlehem piece functioned much as it did on the earth platforms.

83. The recoil of the carriage on the ground was practically zero for all three systems. The counter recoil of the carriage on the ground was zero for the Ehrhardt and Ordnance Department carriages, and for the Bethlehem at maximum elevation; at zero elevation the latter counter recoiled several inches, and at maximum depression it averaged 14 inches.

84. During the firing on this platform the Bethlehem spade was cracked and the lower corners bent inward. The lower edges of the Ehrhardt spade were slightly bent. The lower edge of the Ordnance Department spade was cracked in two places and bent inward. The Bethlehem and Ordnance Department spades were straightened in the open air by a smith and helper, using an ordinary field forge, and thus straightened were used through all the tests.

85. At the conclusion of the test on the rock platform, the Bethlehem trail was jammed on the axle so that the piece could not be traversed. The jamming was due to the springing of the axle, which was undoubtedly caused by the jump of the wheels on the rigid platform. The lower side of the axle was filed off until the trail moved freely in traversing; a machinist was employed a day and a half in doing this work.

86. The Ehrhardt elevating mechanism worked exceedingly hard toward the end of the firings on this platform. Investigation showed that the inner elevating screw was bent, top to the right. This screw has at its upper end a horizontal shank which extends to the right and supports the traversing table. The screw was bent by the cross strain brought upon it when the gun was in its recoiled position. It was taken to the machine shop and straightened so as to work satisfactorily.

MACADAM PLATFORM.

87. The surface of this platform was very hard and the spades uniformly failed to take hold. The Ehrhardt spade, which is fitted with a point, managed to hold that carriage in firing position at 3 rounds, but at all others it failed to do so.

The wheel shoes were used on the Bethlehem wheels. This reduced the average recoil of that carriage at zero elevations to 51 inches, compared with 72 inches for the Ehrhardt and 65 inches for the Ordnance Department carriage.

88. There was no jump of the wheels of the Ehrhardt and Ordnance Department carriages. The wheel shoes of the Bethlehem caused the wheels of that carriage to rise from 4 to 8 inches at each round.

The lateral movement of the wheels could not be measured with accuracy on account of the excessive recoil of the wheels on the ground. The departure from the line of fire was very irregular, varying from 2 to 3 degrees at all elevations of the Ehrhardt and Ordnance Department pieces. The wheel shoes threw the Bethlehem piece much farther off the line of fire; at maximum elevation its departure averaged 12 degrees; at zero elevation, 20 degrees, and at maximum depression, 40 degrees.

89. The recoil of the carriage on the ground necessarily reduced the recoil of the piece on the carriage. For the Bethlehem this varied from 22 to 28 inches, and for the Ordnance Department piece from 31 to 40 inches, depending on the elevation and the length of recoil of the carriage on the ground.

90. The Ordnance Department piece counter recoiled fully into battery after each round. The Ehrhardt stopped 7.25 inches out of battery at one round and was shoved in by hand. It was thought that the counter-recoil springs were weak, and two new sections of springs were substituted for the two shortest ones in the spring column. At all rounds thereafter the piece returned fully to battery.

91. The failure of the Bethlehem piece to return fully to battery was the cause of delays in this firing, as it had been in that done on other platforms. There were constant small leakages from the cylinders. The pistons in the spring cylinder were examined, and it was found that the manufacturers had failed to put springs under the leather packing. This omission was supplied and the stuffing box was repacked.

TRAIL RIGIDLY SUPPORTED.

92. Twenty rounds were fired from each of the long-recoil carriages with the trail rigidly supported by an oak post set into the ground and braced to prevent yielding.

The Ehrhardt carriage was fired with extended trail, the lunette resting against the oak post. There was a slight jump of the wheels, but no departure from line of fire and no lateral movement of the carriage. Ten of the 20 rounds were fired in 1 minute and 36 seconds, with no attempt at great rapidity.

The Ordnance Department long-recoil carriage was placed on the platform with the lunette resting against the oak post. The first 10 rounds were fired in 1 minute and 50 seconds, with no unusual attempt at rapidity; the second 10 rounds were fired rapidly in 31 seconds. There was no departure of the piece from the line of fire and no movement of the piece on the platform during the 20 rounds. These carriages were not injured in any way by this test.

The Bethlehem carriage was placed on the platform with the lunette resting against the oak post. At the end of 5 rounds the lunette was bent upward and an incipient crack developed. As it was quite evident that it would be broken off, or at least damaged beyond repair, if the test were continued without change in the point of support of the trail, an oak timber was placed between the spade and the post, so that the lunette would be relieved of all strain. The test was then completed, 10 of the 15 rounds being fired rapidly in 38 seconds. There was no departure of the piece from line of fire and no lateral movement of wheels during the test. The wheels jumped about 3 inches at each round and were embedded 3 inches in the platform as a result of the last 15 rounds.

MOISTURE, HUMIDITY, AND EXPOSURE TESTS OF AMMUNITION.

93. The moisture test consisted in immersing 10 rounds in water for 5 minutes and then allowing them to stand 24 hours before firing. For a humidity test 10 rounds were subjected to a temperature of 100° F. and a relative humidity of 95° for thirty days and then fired. In the exposure test the limber chests, filled with ammunition, were exposed to the weather for two weeks and then examined and part of the contents fired.

The Armstrong, Cockerill-Nordenfelt, and Vickers-Maxim cartridges were not subjected to these tests, for the reason that they were assembled at the proving ground without resizing of cases, and consequently were not waterproof.

The Bethlehem ammunition stood the moisture and exposure tests without its ballistic characteristics being affected. That subjected to the humidity test showed an increase of about 45 feet per second in muzzle velocity.

The Ehrhardt ammunition was not affected by the moisture and exposure tests, but showed an increase of 45 feet per second in muzzle velocity, with a corresponding increase in pressure, as a result of the humidity test.

The Ordnance Department ammunition showed no change in ballistic properties as a result of the moisture and exposure tests. The ammunition subjected to the humidity tests gave somewhat irregular results, with an average increase of 46 feet per second in the velocity and corresponding increase in the pressure. In the exposure test both Ordnance Department limbers were used, and part of the contents of each were fired.

DUST TEST.

94. For this test the mechanisms were cleaned and lightly oiled, and then exposed to a blast of fine dust in such a manner as to be uniformly and equally covered with dust. Ten rounds were then fired with elevations from 2 to 10 degrees and from one extreme to the other in azimuth, and the time noted.

In the Cockerill-Nordenfelt, Ordnance Department short-recoil, and Vickers-Maxim systems the breech mechanisms alone were dusted; in the other systems tested the carriage mechanisms were included. After dusting, the parts were wiped off with the bare hands if considered desirable, the time required to do this being included in the time of firing the following round.

System.	Date.	Time required to fire—				Remarks.
		1 round.	2 rounds.	5 rounds.	10 rounds.	
	1902.	*m.* *s.*	*m.* *s.*	*m.* *s.*	*m.* *s.*	
Bethlehem No. 2	Apr. 22	3 29	3 43	5 54	9 44	
Cockerill	Mar. 13	1 40	4 14	6 50	7 16	Time given for 9 rounds only.
Ehrhardt	Mar. 17	2 9	2 39.5	10 8	11 30	Fifth round required 6 minutes and 13 seconds.
Ordnance Department short recoil.	Mar. 13	0 5.5	0 12.5	0 33	1 0	No difficulty whatever in firing.
Ordnance Department long recoil.	Mar. 15	0 10	0 18	0 32	0 50	Do.
Vickers-Maxim	Mar. 14	1 25	2 5	3 40	4 23	

The elevating and traversing mechanisms all worked without difficulty. At several rounds the Bethlehem No. 2 and Ehrhardt pieces remained some distance out of battery and were shoved in by hand.

The Bethlehem No. 2, Cockerill-Nordenfelt, Ehrhardt, and Vickers-Maxim breechblocks each rotated with difficulty for a few rounds, and the movement was forced in each case by striking the operating lever handle with a piece of timber. The Bethlehem mechanism was finally slushed with oil. At first some of the Ehrhardt cartridges could not be forced home. This was remedied by sponging out the recess and chamber. At the fifth round the Ehrhardt extractor became jammed on account of dirt in the extractor groove and prevented the opening of the block. The mechanism had to be dismounted and the groove cleaned.

RUST TEST.

95. For this test the parts were cleaned of all oil and residue and then treated with a rusting solution, after which they were permitted to stand until thoroughly and uniformly rusted before firing. The breech was then opened and 10 rounds were fired rapidly, time being noted. During the firing the piece was changed in elevation from 2 to 10 degrees, and in azimuth from one extreme to the other.

After the breech had been opened, the use of oil and wiping of the parts with the bare hands were permitted, the time required being included in the time of firing. In the Armstrong, Cockerill-Nordenfelt, Ordnance Department short recoil, and Vickers-Maxim systems, the breech mechanisms alone were rusted. In the other systems tested the carriage mechanisms were included in the rusting process.

	Date.	Time to open breech.	Time required to fire.				Time to open breech and fire 10 rounds.	Remarks.
			1 round.	2 rounds.	5 rounds.	10 rounds.		
	1902.	*Secs.*	*Secs.*	*Secs.*	*Secs.*	*Secs.*	*Mins. secs.*	
Armstrong	Mar. 20	1.2	20	31	....	....	....	Not well rusted, on account of nickel plating. Blowback wrecked mechanism at third round.
Bethlehem No. 2 .	Apr. 25	15	85	96	111.5	133	2 28	Well rusted. Test included carriage mechanism.
Cockerill	Mar. 24	16.4	54	61	82	108.5	2 4.9	Well rusted.
Ehrhardt	...do	39.5	29	36	97	190.5	3 50	Well rusted. Test included carriage mechanism.
Ordnance Department short recoil.	Mar. 20	3	2	6	17	32	35	Well rusted.
Ordnance Department long recoil.	Mar. 24	66.5	41	44.5	55	72.5	2 19	Heavily rusted. Test included carriage mechanism.
Vickers-Maxim ..	Mar. 20	1.5	2	8	25	47.4	48 9	

All of the pointing mechanisms worked without difficulty. The Bethlehem No. 2, Cockerill-Nordenfelt, Ehrhardt, and Ordnance Department long recoil breech mechanisms had to be forced open by striking the operating lever handle with a heavy piece of copper.

The Bethlehem No. 2 gun remained out of battery an increasing distance at each round. After the last round it was about 10 inches out and oil issued in a small stream from the cylinder.

At the first round the Ehrhardt piece remained about 8 inches out of battery, and was fired from that position, blowing the rubber counter-recoil buffer from its fastening. Test was stopped and buffer replaced by 2 men in 8 minutes, time not included in above table. Piece remained 8 inches out of battery at second round and was shoved in by hand.

EXCESSIVE CHARGES.

96. Ten rounds were fired from each piece in groups of two with pressures increasing to 44,000 pounds, or one-third greater than the standard. The results, stated in the next table, were without unusual incident, except several blowbacks in the Cockerill gun, which injured the firing pin. Primers furnished from the Frankford Arsenal were used in the Armstrong ammunition, and gave no blowbacks.

Excessive charges.

System.	Date.	35,000 pounds.		38,000 pounds.		40,000 pounds.		42,000 pounds.		44,000 pounds.		Remarks.
		Charge.	Pressure per square inch.	Charge.	Pressure per square inch.	Charge.	Pressure per square inch.	Charge.	Pressure per square inch.	Charge.	Pressure per square inch.	
		Ounces.	*Pounds.*	*Ounces.*	*Pounds.*	*Ounces.*	*Pounds.*	*Ounces.*	*Pounds.*	*Ounces.*	*Pounds.*	
Armstrong	July 17	27.5	37,100	28	38,860	28.5	42,520	28.5	42,740	28.87	44,380	At 8 rounds case stuck in its seat, but was extracted.
		27	37,520	28	42,100	28.25	42,540	29	43,640	29	45,920	
Bethlehem No. 2	July 14	21.25	37,000	22.75	38,660	22.5	a 40,000	22.25	43,100	23.25	44,160	
		21.75	37,800	22	39,260	22.37	40,360	23	43,600	23.25	44,160	
						22.37	a 40,000					
Cockerill-Nordenfelt	July 15	23.5	36,800	24.37	38,060	25	40,220	25.25	43,840	25.5	44,160	5 blowbacks due to high pressure. Firing pin injured and replaced by new one. Ordnance Department powder used.
		24	37,700	24.75	39,160	25.25	43,740	25.37	44,160	25.62	44,820	
Ehrhardt	July 11	28.25	35,540	29	39,440	29.75	43,240	30.37	43,760	30.5	44,920	Two cases extracted with some difficulty
		28.37	37,360	29	41,240	29.5	43,640	30.12	43,940	30.62	45,220	
Ordnance Department short recoil.	July 15	27.5	38,330	28	40,090	28.25	41,840	28.5	43,020	29	44,800	
		28	b Lost.	27.5	41,240	28.25	41,930	28	44,400	28.5	46,840	
		28.25	b Lost.									
Ordnance Department long recoil.	July 11	27	37,520	27.5	38,860	27.5	40,540	28.25	42,020	28.62	44,600	
		27.5	38,660	27.87	39,900	28	41,040	28.25	42,220	28.69	45,420	
Vickers-Maxim	July 10	18	36,720	18.62	39,160	18.62	40,000	19.25	42,940	19.5	44,100	
		18.37	38,060	19	39,750	19	40,100	19.25	42,940	19.62	45,200	

a Estimated; record lost.

b Estimated at more than 40,000 pounds per square inch.

DEFECTIVE AMMUNITION.

97. *Defective cartridge cases.*—The different mechanisms were subjected to a firing test of 10 rounds with cases weakened by thinning the metal along an element from a point 2 inches from the head to a point 2 inches from the mouth of the case. Practically all the cases thus weakened split open in firing.

The breech mechanisms of the two Bethlehem guns being similar, that of the No. 3 gun was not subjected to test. The mechanisms tested functioned satisfactorily except the Armstrong, Cockerill-Nordenfelt, and Ehrhardt. With the Armstrong some slight difficulty was experienced in extracting the empty cartridge cases, while the eccentric screw mechanisms of the Cockerill-Nordenfelt and Ehrhardt guns were found deficient in ejecting power, so that 19 out of 20 cases had to be rammed out from the muzzle.

98. *Blow backs.*—Two rounds were fired from each piece with percussion primers, thinned so as to cause blow backs. The Armstrong mechanism was not subjected to this test, experience in earlier tests showing that a broken firing pin and mainspring invariably resulted from a blow back.

The Bethlehem No. 2 required slight repairs after first blow back; the second one blew the firing pin violently to the rear, stripping off its point and jamming it in the housing. The mainspring was permanently shortened.

The Cockerill-Nordenfelt and Ehrhardt mechanisms have similar firing pins. At each of the blow-back tests with these pieces the guide slot in firing pin was closed in over the guide stud in the housing, jamming the pin in its seat and requiring repairs before the next round could be fired. The Ordnance Department short-recoil firing pin was driven to rear and jammed in sear housing at each round. At second round the cam lug on firing pin was damaged and new pin had to be substituted.

The Ordnance Department long-recoil mechanism was uninjured at first round. At second round two lugs of breechblock bushing were broken off and cocking lever was broken. Repairs were made and a third blow back was fired, breaking the firing pin at the base of the recocking-piece thread. A new pin was assembled and five blow backs then fired without injury to mechanism.

The first round from the Vickers-Maxim sheared off the screw which secures the cams in the firing-pin recess. At the second round the pin jammed in its seat, due to fouling. The mechanism was uninjured.

VIBRATION TEST OF LIMBER AND AMMUNITION.

99. The vibrating table comprises a platform mounted upon an axle to allow a rocking movement of 13 degrees inclination on each side from the horizontal. On the table is a slide to which the limber (with the wheels removed) is fastened. This slide is 16 inches shorter than the table. The table is operated by a crank and moved successively to extreme inclination, first on one side and then on the other. As the table is inclined the slide carrying the limber frame and ammunition chest moves down the 16 inches length of incline and is brought suddenly to a stop by solid buffers at the end of the table, causing a severe jar. The speed is regulated to move the limber from one end of the table to the other about six to eight times per minute.

Each limber, with chest completely filled, was mounted on this table and subjected to jarring for 48 hours. A careful examination was then made and some of the ammunition was fired to see if the serviceability had been affected. Ten rounds were immersed in water for 5 minutes and then allowed to stand for 24 hours, after which they were fired and results noted.

The limbers were mounted on the table in such manner that the ammunition would be vibrated endways for one-half the period of the test and sideways for the other half.

The ammunition used was fixed and consisted of sand-filled shell closed with blank plugs.

100. The Armstrong limber, when filled, carries 40 rounds of ammunition, but as there were but 36 available for the test it was conducted with that number of rounds in the chest. The limber stood the test without injury. Examination of the ammunition showed that as a result of the test several of the percussion primers were partly unscrewed and that 28 out of the 35 cartridge bags were worn through at the rear end where the black powder igniter comes in contact with the screw primer of the case. This resulted in spilling the black powder into the cartridge case. New cartridge bags and igniters were substituted for the damaged ones and a few rounds fired for velocity with satisfactory results. The moisture test of this ammunition was omitted, as the projectiles fitted loosely in the cases and there were no means at hand of properly resizing the latter.

101. The Bethlehem limber, with chest filled with 44 rounds of ammunition, was tested for 45 minutes, when one of the springs supporting the chest was broken.

The broken part was repaired and the limber strengthened by the addition of clamps to the springs and of stay chains, fastened to the axle, to limit the upward movement of the chest. The test was then resumed and continued for 6½ hours, when it was suspended on account of the breakage of some of the stay-chain fastenings and of the links connecting the chest to the rear ends of the springs.

The limber was again repaired. New and much stronger springs and connections replaced the old ones. The test was then resumed and continued for 18 hours, when it was stopped by the failure of the eye leaves of the three chest springs. The limber was subsequently repaired for the field test, but no further attempt to complete the vibration test was made.

102. The Cockerill-Nordenfelt limber, with 40 rounds of ammunition, endured this test practically without injury, the breaking of a fastening on the limber door being the only damage noted. The ammunition was in good condition and firings with it gave satisfactory results. As the ammunition was reloaded at the proving ground without resizing of cases, the moisture test was omitted.

103. The Ehrhardt limber, with 36 rounds of ammunition, stood the test without injury to limber or ammunition. Part of the latter was fired for velocity and gave excellent results, both before and after the moisture test.

104. The Ordnance Department short-recoil limber, with chest filled with 40 rounds of ammunition without primer shields, was tested for 6 hours before the omission of the primer shields was noted. They were then put on the cases and the test continued for 9 hours longer, when the fastenings of the chest door gave way, the door opened, and

27 rounds of ammunition were thrown upon the floor. Several of the cartridge cases were badly dented, but otherwise the ammunition was uninjured. Five of the ammunition tubes in the chest were damaged. The fastenings of the door were undoubtedly weakened by the hard usage the door received, due to the omission of the primer shields.

The limber was repaired and strengthened and filled with new ammunition. It then endured the prescribed test without injury to chest or contents. Part of the ammunition was fired for velocity, with excellent results. This ammunition is the same as that used in the Ordnance Department long-recoil piece, and the moisture test of the vibrated ammunition was conducted in connection with the test of that piece.

105. The Ordnance Department limber belonging to the long-recoil carriage, with 40 rounds of ammunition, was vibrated for 5.5 hours, when one of the chest springs was broken and the test was suspended. The broken spring was repaired and both springs and the chest door were strengthened. The test was then begun anew and continued for the prescribed time, 48 hours. At the end of 43 hours of the test three leaves of one of the springs were broken; the eye leaf of this spring was still intact and strong enough to complete the test. The spring was subsequently repaired in preparation for the field tests.

The ammunition was in good condition, and when fired for velocity gave excellent results both before and after the moisture test.

106. The Vickers-Maxim limber, with chest filled with 40 rounds of ammunition and rigidly clamped to the vibrating table, was tested for 11 hours. As this method of fastening the chest eliminated the effect of the limber springs, it was changed so as to test them and to conform to the test to which other spring limbers had been subjected. With the altered fastenings the test was continued for 17 hours, when one of the springs was broken. The spring was repaired in preparation for the field tests, but the vibration test was not completed.

FIELD TESTS.

107. The field tests of this material were conducted at Fort Riley, Kans., by the Sixth Battery of field artillery, Capt. Granger Adams, commanding. The instructions from the War Department directed that a field march of 150 miles be made, the march to include all maneuvering necessary to constitute every field test of the material considered desirable for the purpose of ascertaining its suitability for the service and to be attended by such firings as would aid in forming a judgment upon this point.

108. The experimental material included in the battery for these tests were the Armstrong, Bethlehem No. 2, Cockerill-Nordenfelt, Ehrhardt, Ordnance Department short and long recoil, and Vickers-Maxim carriages and limbers fully equipped. A 3.2-inch service carriage and limber, with equipments, was added for purpose of comparison only. The Bethlehem No. 2, Ehrhardt, Ordnance Department long recoil, and 3.2-inch pieces were supplied with shrapnel, while all were provided with filled and fused shell except the Ehrhardt, for which, due to a mistake of the manufacturers, the proper fuses were not received, and sand-filled shell were used.

The foreign limbers were fitted with pole chains, and two of them (Ehrhardt and Cockerill-Nordenfelt) with a system of pole draft.

After a short test it was found that the service system, using the neck yoke and continuous-trace draft, was decidedly preferable. The foreign limbers were accordingly altered to the service system.

109. The road tests embraced marches over the most difficult roads and trails to be found on the Fort Riley Reservation, followed by a march of 150 miles over country roads to Topeka, Kans., and return. All of these marches were made under service conditions with the limber chests filled with filled and fused ammunition. The total distance covered in the tests was approximately 223 miles.

Considered as vehicles, the carriages passed through the tests practically without injury, such repairs as were required being of a minor character and easily made in the field.

110. The firings in general were at standard land targets (12 by 14 feet), distant about 6,200 yards; at groups of D silhouettes, in column of fours, distant 3,500 to 4,000 yards, and at a spool target moving across the line of fire at ranges of from 1,000 to 2,000 yards. Shell were used at the long range and shell and shrapnel at the short ranges. The practice throughout was excellent. The superior accuracy of the new to the service material at extreme ranges was quite apparent, while at medium and short ranges, with rapid fire and moving targets, the movement of the target being followed by the traverse of the piece, there could be no comparison.

The different carriages in firing acted in most respects as in the general tests at the proving ground, heretofore described. The short recoil pieces were fired for information merely, the carriages as a type for adoption having been rejected. The Bethlehem No. 2 piece continued to give trouble by failing to return to battery and by leakage from the cylinders. On two occasions the piece remained 40.5 inches out of battery, due to the jamming of the piston in the rear end of the cylinder. Considerable difficulty was encountered in returning the piece to battery.

The Ehrhardt piece remained a short distance out of battery at a few rounds at extreme range, but after cleaning and oiling of sliding parts again worked properly.

The Ordnance Department long recoil piece for a number of rounds remained from 1 to 2 inches out of battery, and could not be shoved in by hand. Examination revealed the presence of a few small tool chips in the female part of the counter-recoil buffer (evidently left there in manufacture). These were removed and the scored parts of the buffer smoothed off, when the piece again returned fully to battery.

111. At the conclusion of the 150-mile road march these pieces were put immediately into action with no attention other than wiping with the bare hands and oiling the gun slides. The Ehrhardt and Ordnance Department long-recoil pieces remained out of battery slightly for the first two rounds each (at 6,200 yards range), but were readily shoved in by hand. The slides on the former were again oiled and the stuffing-box glands on the latter slightly released, and thereafter both functioned properly. The Bethlehem No. 2 piece stuck 40.37 inches out of battery at the third round and 15 minutes were required to put it in firing condition. Thereafter it worked as usual.

112. The telescopic sights furnished with the Ordnance Department sights were most favorably regarded by the officers who inspected them. The advantage of having such a sight was strikingly shown on two occasions, when the gunners of other carriages had to use field

glasses to find the targets and then attempt to aim their pieces through open sights at the point so located. Through the telescopic sight the targets were distinctly visible and the piece was laid directly on them.

The tests emphasized the fact that the proper range graduation of a sight is yards, not degrees, and that the proper deflection graduation is points each equivalent to one one-thousandth of the range. The battery commander notes that a shot is so many yards over or short, right or left, of the target. His sight should be graduated so that he can apply the correction directly, and not have to convert yards into degrees and minutes before doing so.

113. The shrapnel for the Bethlehem No. 2 and Ordnance Department long-recoil pieces were fitted with the service combination fuse and gave irregular results. The action of the Ehrhardt fuse was quite uniform, and the shrapnel fire from that piece, in consequence, gave very satisfactory targets. The service combination fuse requires a special tool and some skill in cutting, and when once cut can not be cut and used for a longer range. For that reason it is urged that it is not suitable for rapid firing, as in such firing fuses must be cut in advance for at least a few rounds.

In action the limbers were habitually posted to the left and a few yards to the rear of the carriages. In this position it was noticed that the ammunition was most expeditiously served from those limbers which were not provided with ammunition carriers. The difference was caused by the time required to pull out and open the carriers or strip off the mantlets and to replace the empty carriers.

114. On the road the Armstrong and Bethlehem carriages were found to be very heavy at the end of the pole, galling the necks of the wheel horses. To relieve this the Armstrong ammunition carriers were reversed in the limber chest so as to bring the projectiles to the rear; to accomplish the same end, one man habitually rode on the Bethlehem trail near the lunette.

The Bethlehem carriage failed to track well, due to the peculiar pintle arrangement. The limbering and unlimbering of the carriage was a slow and inconvenient operation for the same reason.

The Cockerill-Nordenfelt carriage was somewhat unwieldy, due doubtless to the use of a splinter bar instead of a doubletree, the unequal draft of the horses causing the limber to wander from side to side of the road. The use of a splinter bar and the application of the traction to the limber frame above the chest springs gave to the Vickers-Maxim limber an unsteady motion.

The actual weight behind the horses of the Ordnance Department long recoil was about the same as that of the Armstrong and Cockerill-Nordenfelt carriages. Judged by the apparent effects, these carriages were about equally fatiguing upon the horses, though the first named should have enjoyed an advantage from its better lubrication of wheels, more accurately balanced pole, and more rational drafting arrangements. Whatever advantage it derived from this source was, however, offset by the increased tractive force necessitated by the small wheels. The Ehrhardt carriage, with slightly larger wheels and much less weight, and the Ordnance Department short-recoil carriage with medium weight and much larger wheels, were much easier upon the horses. In general, the observations made in these tests confirm the theoretical deduction that increased tractive force and consequent horse fatigue is a necessary consequence of the reduced size of wheels used in the long-recoil carriages.

115. On the march the cannoneers were frequently ordered to mount on the limbers while the battery was in motion. For those limbers which were provided with backs to the chest seats this was a difficult and at times dangerous feat, as the cannoneers had to climb up in front of and over the wheels, or else over the back of the seat. The general opinion prevailed that the backs were inconvenient and unnecessary and should be dispensed with. The axle seats on the carriages with back and side rests were very comfortable, easy to get into, and were usually the first seats occupied when permission to mount was given.

All of the road brakes were frequently used and were efficient; the lever brakes on the Ordnance Department long-recoil carriage was the quickest and most convenient to apply and release.

116. At the conclusion of the road march the actual weights of the different carriages and limbers with their equipments and ammunition were taken and found to be as follows:

	Pounds.
Armstrong	4,310
Bethlehem No. 2	4,079
Cockerill-Nordenfelt	4,341
Ehrhardt	3,970
Ordnance Department short recoil	4,159
Ordnance Department long recoil	4,343
Vickers-Maxim	4,225
3.2-inch	3,900

CONCLUSIONS.

1. The total number of rounds fired in the test comprises Armstrong, 74; Cockerill-Nordenfelt, 213; Ordnance Department short recoil, 351; Vickers-Maxim, 162; Bethlehem No. 3, 209; Bethlehem No. 2, 625; Ehrhardt, 654; Ordnance Department long recoil, 709. Test of the systems embodying carriage recoil and short recoil of gun on carriage were discontinued after trials which established the superiority of long-recoil systems; of the latter the Bethlehem No. 3 failed utterly in endurance and other requisites, and its trial was also discontinued, and, finally, but three systems, namely, Bethlehem No. 2, Ehrhardt, and Ordnance Department long recoil were subjected to all the tests contemplated.

2. The Bethlehem No. 2 system did not withstand a satisfactory test either as regards the carriage or the breech mechanism of the gun. The recoil system failed repeatedly to operate properly, and the defect of axle traverse was conclusively shown, aside from other objections, when traversing was prevented by a slight bending of the axle in firings from rock platform. In general, also, this system lacked sufficient steadiness under fire—the jump of the wheels is excessive, and it could not be served by cannoneers sitting upon the trail. The breech mechanism proved defective in the form of the thread, which permits the block to be easily wedged in its seat, and the carrier latch worked with difficulty when dusted. The link connecting the operating lever and breechblock was broken, and the lever handle also. A further serious objection is the method of assembling the firing pin and spring, by which a prohibitive length of time is required to replace one of these parts in case of breakage.

3. The Ehrhardt material is the only one of the whole number tested in which the total weight allowed behind horses (cannoneers excepted)

falls within the limit of 3,950 pounds prescribed by the programme. The performance of this material, on the whole, including ammunition with time fuse, proved very creditable. Few occasions arose in which any stoppage of fire was required, and the repairs necessitated were such as could be readily and quickly made at the gun, with the exception of repairing the elevating screw and replacing the separators in the counter-recoil spring column.

The following objections to this material are noted:

The carriage system.—The elevating screw is placed at the side of the trail and is subjected to a bending moment, which caused the screw to work badly and necessitated shop repair. The telescoping form of trail can give rise to a loss of time in operation at critical moments, and is subject to be rendered inoperative, as regards closing more especially, by any injury to the finished sliding surface. The tubular trail does not lend itself readily to a suitable attachment to the axle, and the form of this attachment, combined with the method of pivoting the cradle, is apparently a source of weakness in the construction. The wheels of the carriage are too small (diameter, 51 inches), and the height of free space above ground, when limbered, being only 12.75 inches, is notably deficient.

4. The advantages of the Nordenfelt breech mechanism with which the Ehrhardt gun is fitted are chiefly safety and simplicity of parts. There is relatively large-threaded surface, and the threads are always engaged. The firing pin is eccentric, and does not come opposite the primer until the block is locked. The threads are not exposed in loading. The hand of the cannoneer can not be caught in loading. No parts project to the rear of the breech, and no tools are required for assembling. The disadvantages of the mechanism are relative slowness of operation combined with restricted motion to force home a cartridge or to eject the empty case, and liability to be disabled by dust or rust. There is a lack of power and movement to force the cartridge into the chamber so as to close the breech. The cartridge must be pushed by hand nearly home, or it will be choked. The ejector frequently fails to throw out a case where sticking occurs from any cause, and recourse must be had to the rammer inserted from the muzzle. The opening in the block allows entrance of dust and dirt, which can collect about the extractor, and the latter fails to work properly unless fairly clean. The mechanism is relatively heavy, and entails a considerable enlargement of the dimensions of the breech.

5. The Ordnance Department long-recoil material gives a weight of 4,289 pounds behind the horses, and the wheels (diameter, 48 inches) are too low. These disadvantages led to a relatively poor showing in the road trials of the field tests. The performance of this material on the firing grounds was good throughout, and marked by fewer interruptions of fire and less need of repairs than any other. On the few occasions when it has failed to return fully into battery it was corrected by slightly releasing the glands of the stuffing boxes, except at one time in the field tests when scoring occurred in the counter-recoil buffers and rendered their removal necessary for cleaning and smoothing off. This scoring was due to small chips of steel which had apparently been inadvertently left in the buffer at manufacture. The steadiness of the carriage in the firing is superior to that of the Ehrhardt, while the latter gave somewhat less carriage recoil, due to the greater surface of the trail spade. The Ehrhardt spade also pre-

sents the better form in being pointed instead of having a straight bottom edge.

The performance of the Gerdom breech mechanism and firing mechanism for this gun was entirely satisfactory except in the blowback test. The failure there was probably due to defective metal, since when a new bushing and firing pin were inserted five blowback rounds were fired without injury. The mechanism, however, needs to be strengthened to obviate injury from blowbacks. The advantages of the interrupted screw mechanism, represented by this type, as compared with the Nordenfelt mechanism, are, to wit: More rapid rate of fire; more power of extraction and ejection and also of rotation; the cartridge does not require to be pushed so far into the breech in loading; the breech is well closed for protection against dust; the parts are simple and easily assembled (without tools), and the whole mechanism has less weight. Disadvantages that may be mentioned are liability of bruising the breech thread or of catching the hand of the cannoneer in loading, and particularly the danger of premature discharge in closing the block, due to the central position of the firing pin, which will strike the cartridge primer if through any cause or accident the point of the pin projects too much from the face of the block.

The first two objections are of secondary importance and seldom occur. In all the firings made in these tests the finger of the cannoneer was once caught and slightly injured, and there was no instance of bruising the threads in loading, although the greatest possible rapidity was attempted with men not trained for the work. The accident of bruising the threads should be less apt to occur with fixed ammunition, which is convenient to handle, than in separate loading. Yet, in the continued service experience with the present field gun, this objection has at least not attained any prominence. The third objection, regarding premature fire from a protruding firing pin, entails consequences so serious that it must be avoided. There are enough instances of record also to make known that it is liable to occur. Where fixed ammunition is used for the interrupted screw mechanism, the firing pin should be eccentric and brought opposite the primer only when the block is locked.

Provided this modification is made, the Gerdom breech mechanism can be considered decidedly superior to the Nordenfelt.

6. Telescopic sights, in addition to the open sights, were provided only with the Ordnance Department systems, but their mounting was not sufficiently firm to be satisfactory. A telescopic sight is deemed essential with the field gun, particularly in the long-range firings which can be so effectively employed with the modern material. Graduation for the range in yards is considered the only kind of graduation for elevation needed.

7. The combination time and percussion fuse (dial setting) furnished with the Ehrhardt material gave more satisfactory results than the service fuse. The irregularity in time of burning observed with the service fuse is not inherent in this pattern and must be attributed to defects of manufacture in the lot of fuses employed in these tests. The chief disadvantage of this pattern, however, is that the setting is not adjustable, and any fuse in which the time train is once cut can not be used for any time greater than that cutting. The importance of this lies in the fact that for the rapid firing of which the present guns are capable the fuses should be set in advance in order to save

time, and it would generally be inadmissible to incur possible waste of a number of fuses by cutting in advance.

8. The vibratory tests of limber are particularly important in their bearing upon the question of mounting the ammunition chest on springs. The integrity of the ammunition (fuses omitted) tested in the limbers without springs was in no degree affected, excepting the Armstrong, wherein the protruding primer abraded the cartridge bag contained in the case. This form of primer is objectionable on other grounds and need not be employed.

The three limbers fitted with springs were all broken down in the tests and one of them only was carried through the test, after modification, with springs badly damaged. The results of these tests show that the ammunition was not damaged by a test that broke down the spring constructions, and that the latter could not be made to withstand the test without increasing their stiffness to such a degree as nearly to preclude any utility as springs and at the same time add largely to the weight of the material.

9. Capt. George W. Burr, Ordnance Department, conducted the tests of material at the proving ground under the supervision of the Board. Captain Burr was also present throughout the field tests, wherein he was charged with the duty of keeping the material, as far as possible, in proper repair and to advise concerning any details wherein the experience of the proving ground could be of value; and also to keep a complete record of the material in general conformity with the rules of the proving ground. The Board invites attention to the care exercised by Captain Burr of both men and material, whereby during very extensive firings no injury to either occurred. The Board desires to express its appreciation of his thorough and efficient service and to acknowledge his assistance in preparing this report.

R. BIRNIE,
Major, Ordnance Department, U. S. A., President.
E. B. BABBITT,
Captain, Ordnance Department, U. S. A.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

Inclosure 1. Copy of programme of tests.
Inclosure 2. Table, data concerning construction and test of material.
Inclosure 3. 34 photographs of material.
Inclosure 4. Plate 1, group of targets at 2,500 yards range.
Inclosure 5. Plate 2, group of targets at 1,000–2,500 and 1,000 yards range.

[Inclosure 1.]

PROGRAMME OF TESTS FOR FIELD ARTILLERY.

WAR DEPARTMENT,
BOARD OF ORDNANCE AND FORTIFICATION,
Washington, D. C., October 22, 1901.

The following is the programme for the tests of field-artillery material to be conducted under the direction of the Board of Ordnance and Fortification:

The tests printed in italics are to be conducted at Fort Riley, Kans. [a]

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[a] Subsequently changed (letter of Secretary of War dated November 20, 1901) to conduct all tests at the Sandy Hook Proving Ground, except those enumerated under "Supplementary tests," paragraph 4.

Requirements.

1. Total weight allowed behind horses, approximately 3,950 pounds.
2. Weight of common shell loaded and fuzed, 15 pounds.
3. Muzzle velocity, 1,700–1,750 feet per second, with a pressure not to exceed 33,000 pounds per square inch.

Manufacturers submitting material for test will furnish gun, carriage, limber, and all tools and equipments complete for assembling, dismounting, care, and service of the piece.

The ammunition required during the tests will be furnished at the expense of the Government.

The powder, in addition to giving the required velocity, shall be of a known and satisfactory composition.

Two cases of ammunition, packed and sealed for shipment, will be furnished.

All projectiles will be delivered filled with sand to the required weight and fuzed with a blank fuse plug.

During the tests the repair of such minor defects as may occur and which can be made without material delay will be permitted. Changes in construction will not be permitted.

Any defect which shows violation of an essential principle of construction will discontinue the tests of the material unless in the opinion of the board further tests are warranted.

Inspection.

1. A careful inspection to be made of the gun. In the breech mechanism the number of parts, their simplicity, strength, and certainty of action to be noted. The ease with which the mechanism can be assembled and dismounted, together with tools necessary for this operation. Special notice to be made of those mechanisms permitting dismounting after any part jams while breech is closed, and special note will be made of those mechanisms permitting a firing of the gun or primer before the breech is closed and locked.

During this inspection ten or more rounds may be fired.

2. A similar inspection of the carriage. In this special note will be made of the following:

(*a*) Weight and construction of wheels.
(*b*) Space between naves.
(*c*) Free space under carriage when limbered.
(*d*) Simplicity and certainty of elevating and traversing gear.
(*e*) Amount of lost motion in these gears.
(*f*) Accuracy of elevating device, including the sight radius or its equivalent.
(*g*) The nature of the devices for limiting the recoil, and, if hydraulic, the kind of fluid to be used in the cylinders and the ease with which the cylinders can be filled.
(*h*) Operation of firing, and road brakes, if any.
(*i*) Ease with which broken parts can be replaced, etc.
(*j*) Ease with which gun can be mounted.
(*k*) Speed with which gun can be elevated and depressed and moved from one extreme to the other in azimuth, and these with wheels level and with one wheel higher than other. Power required on handwheels or cranks to be noted.
(*l*) Location of sights for easy and quick laying, especially while loading.
(*m*) The number of bearing surfaces, the facility for cleaning them, and the means provided for proper lubrication.
(*n*) Length of trail and weight on trail in limbering.
(*o*) An examination of the calculations on which the strength of various parts were determined. For this purpose the calculations should be submitted with the description of the carriage. It is desirable that one rotation of the elevating wheel or crank should correspond to an even reading in elevation.

Firing Tests—Special.

VELOCITY.

Velocities and pressures will be taken at once to determine whether or not ballistic requirements are fulfilled; and at such times as may be necessary to insure the maintenance of these conditions.

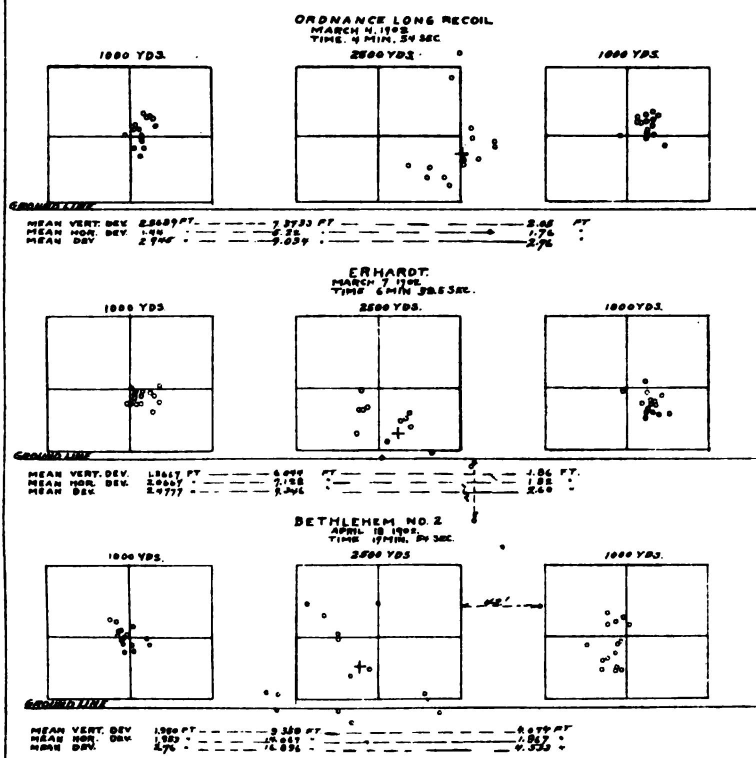
MAINTAINED RAPIDITY FIRING

FROM CLAY PLATFORM

SCALE – 20 FEET TO THE INCH.

NOTE – SHOTS NOTED IN THE FIRING RECORDS AS RICOCHETS AND MISSES ARE PLOTTED AT THE INTERSECTION OF THE TRAJECTORY WITH THE PLANE OF THE VERTICAL TARGET.

5 ROUNDS, EACH TARGET.



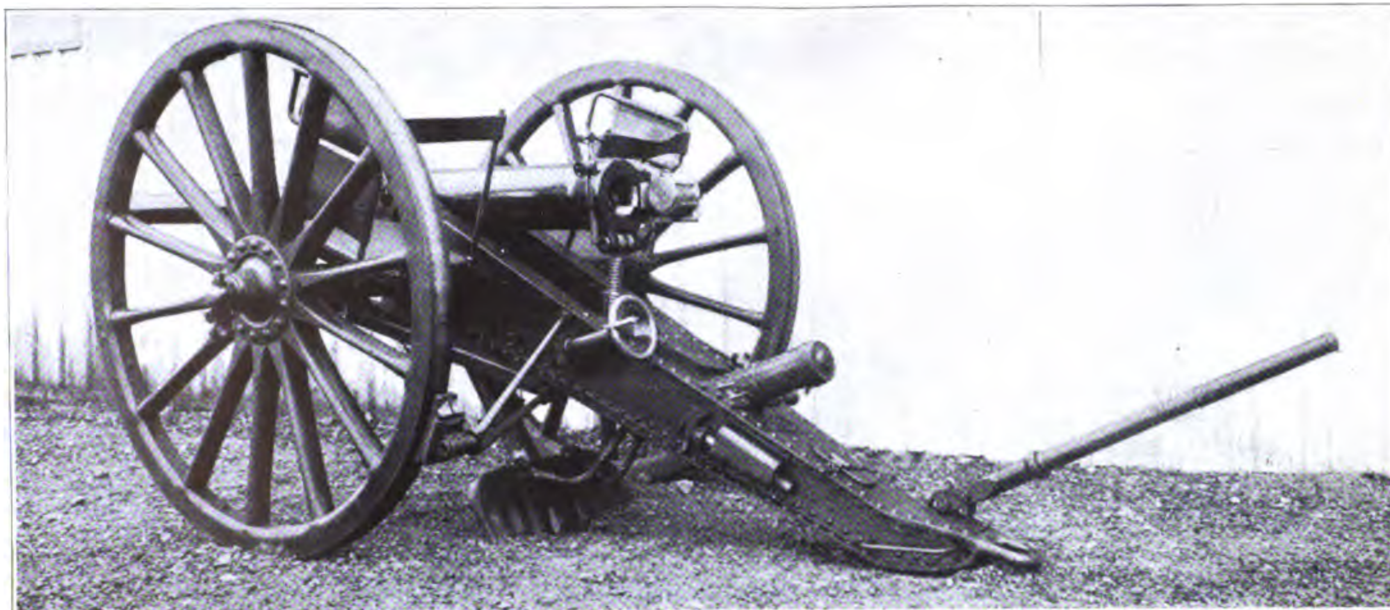
Ordnance Board U.S.A. Aug. 18, 1902.

R. Birnie

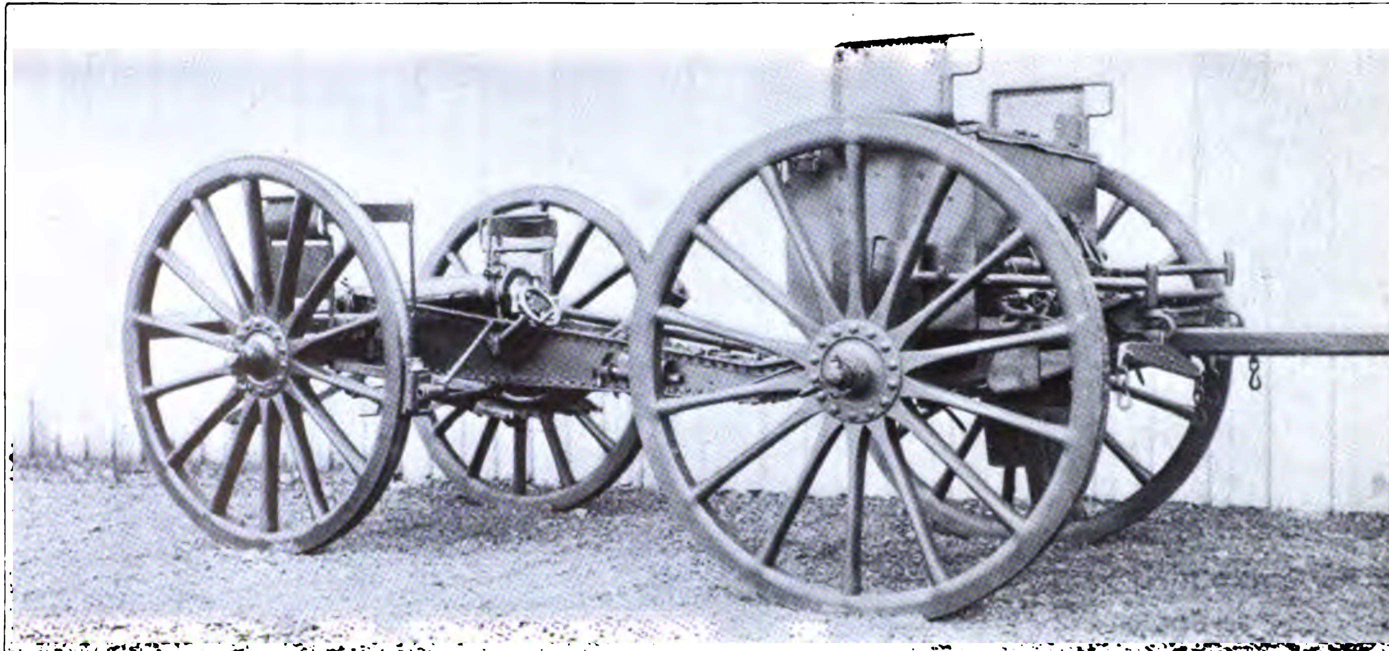
Major. Ordnance Dept. U.S.A.
President.

1. ARMSTRONG BREECH MECHANISM.

Appendix IV, 1902.



2. ARMSTRONG CARRIAGE IN FIRING POSITION.

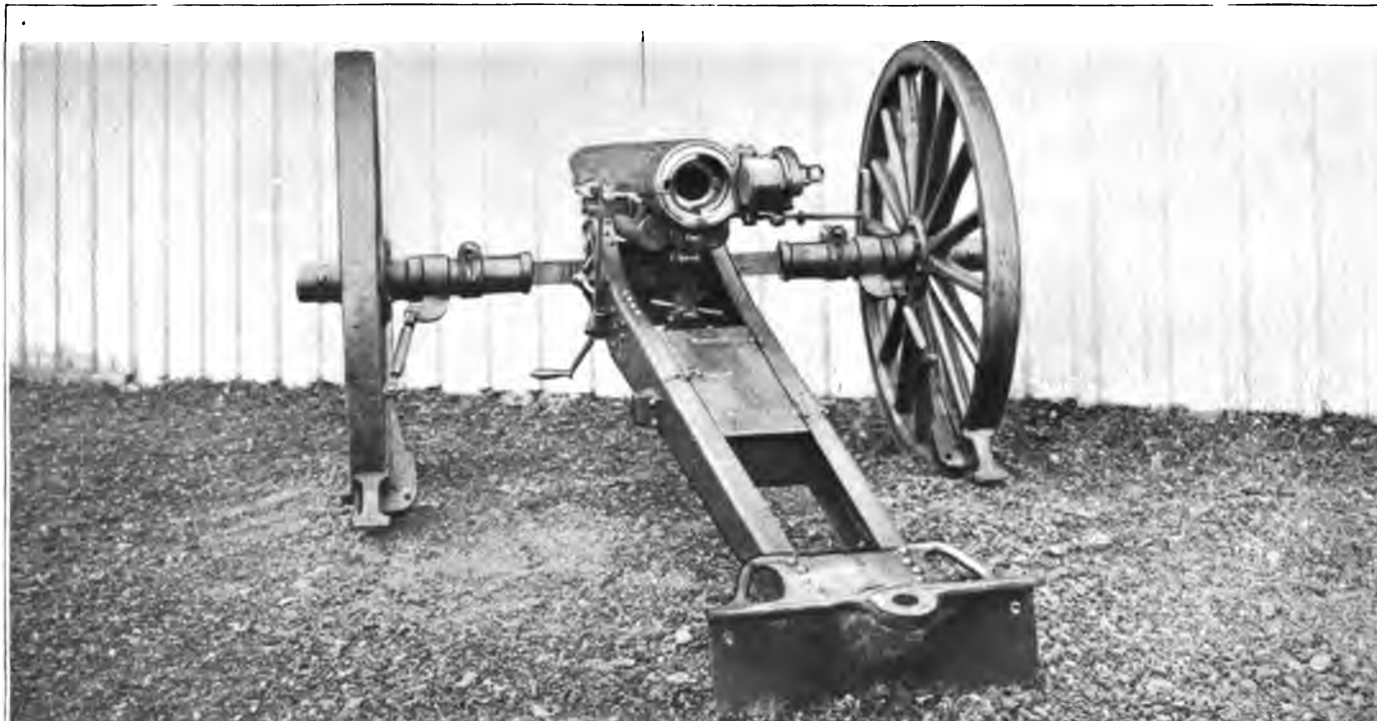


3. ARMSTRONG CARRIAGE LIMBERED.

4. ARMSTRONG LIMBER.

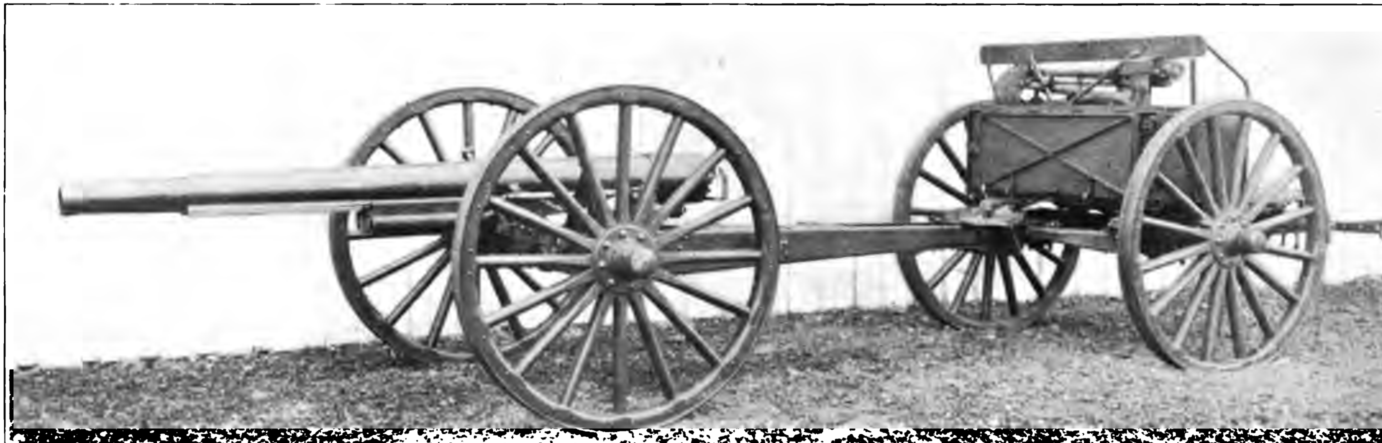
Appendix IV, 1902.

5. BETHLEHEM BREECH MECHANISM.

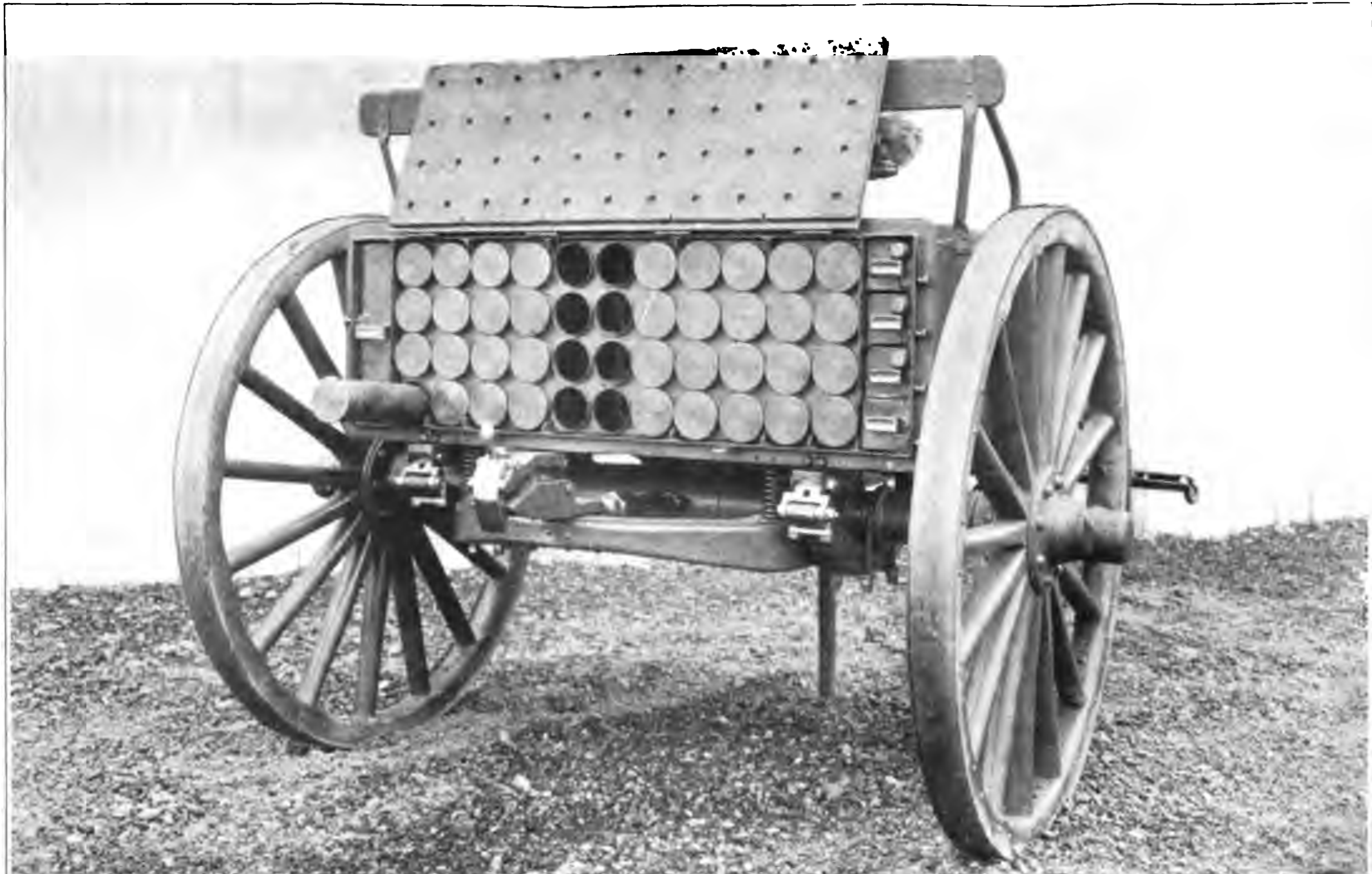


6. BETHLEHEM NO. 2 CARRIAGE—REAR VIEW.

7. BETHLEHEM NO. 2 CARRIAGE—FRONT VIEW.



8. BETHLEHEM NO. 2 CARRIAGE LIMBERED.



9. BETHLEHEM LIMBER.

Appendix IV, 1902.

10. BETHLEHEM NO. 3 CARRIAGE—REAR VIEW. WHEEL SHOES IN FIRING POSITION.

Appendix IV, 1902.

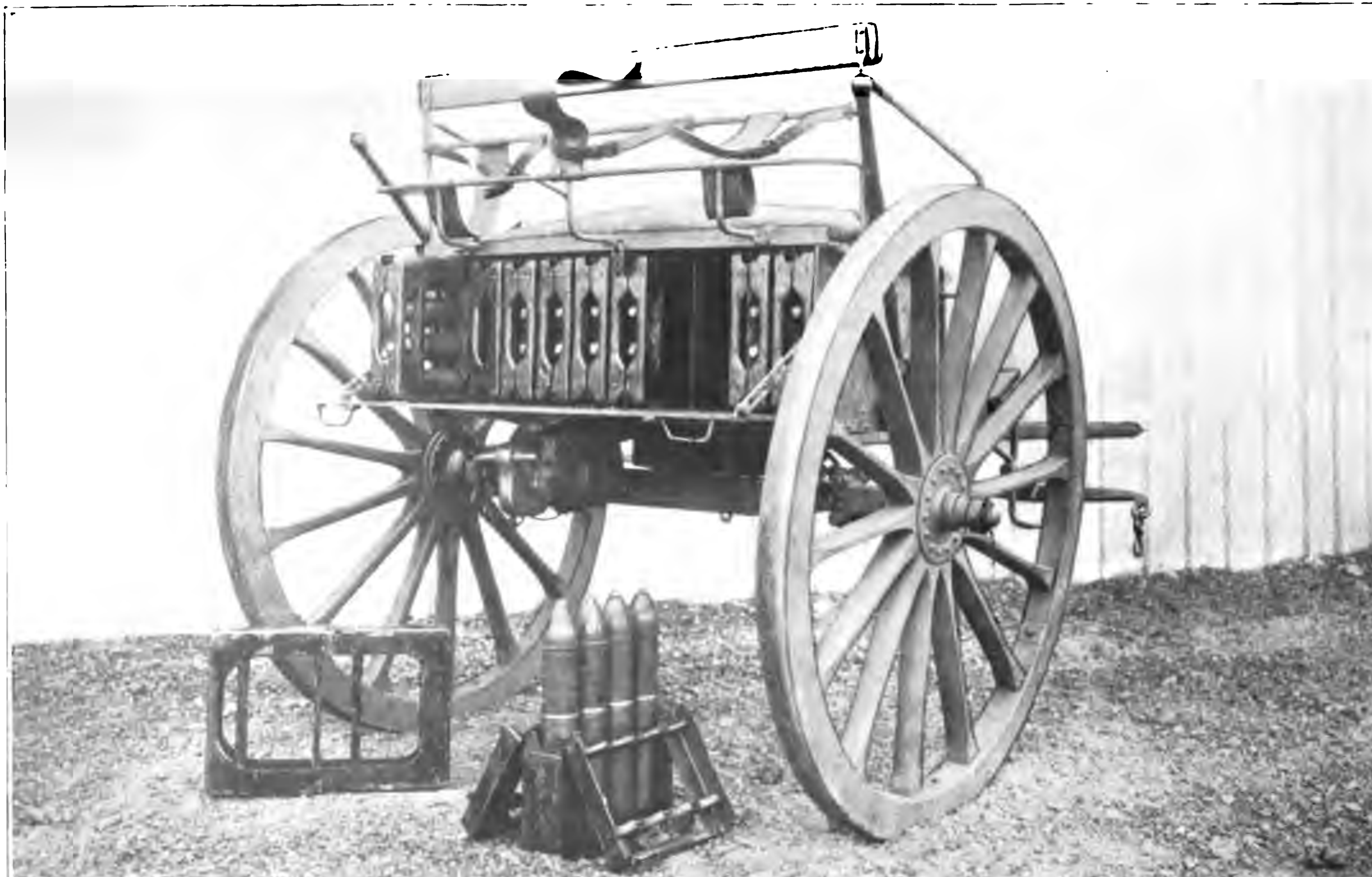
11. BETHLEHEM NO. 3 CARRIAGE—FRONT VIEW. WHEEL SHOES IN TRAVELING POSITION.

12. COCKERILL-NORDENFELT BREECH MECHANISM.

13. COCKERILL-NORDENFELT CARRIAGE IN FIRING POSITION

Appendix IV, 1902.

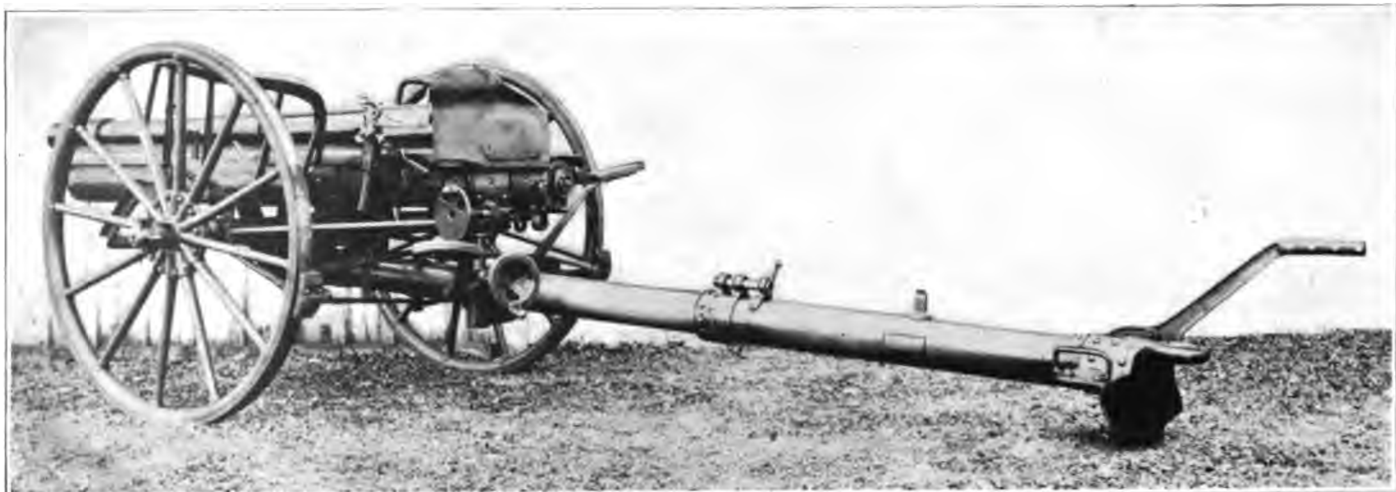
14. COCKERILL-NORDENFELT CARRIAGE LIMBERED.



15. COCKERILL-NORDENFELT LIMBER.

Appendix IV, 1902.

16. EHRHARDT BREECH MECHANISM.

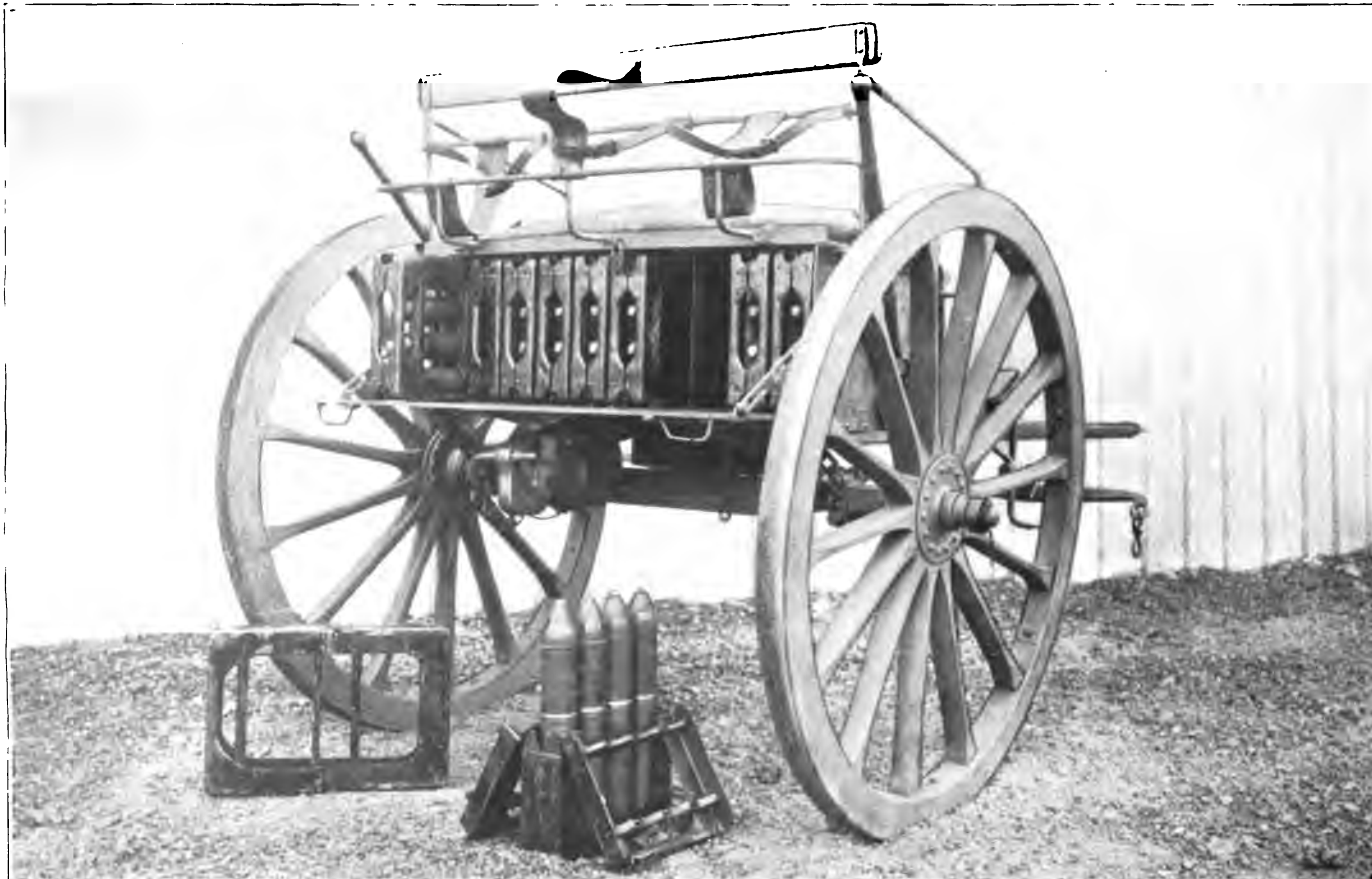


17. EHRHARDT CARRIAGE IN FIRING POSITION WITH TRAIL EXTENDED.

Appendix IV, 1902.

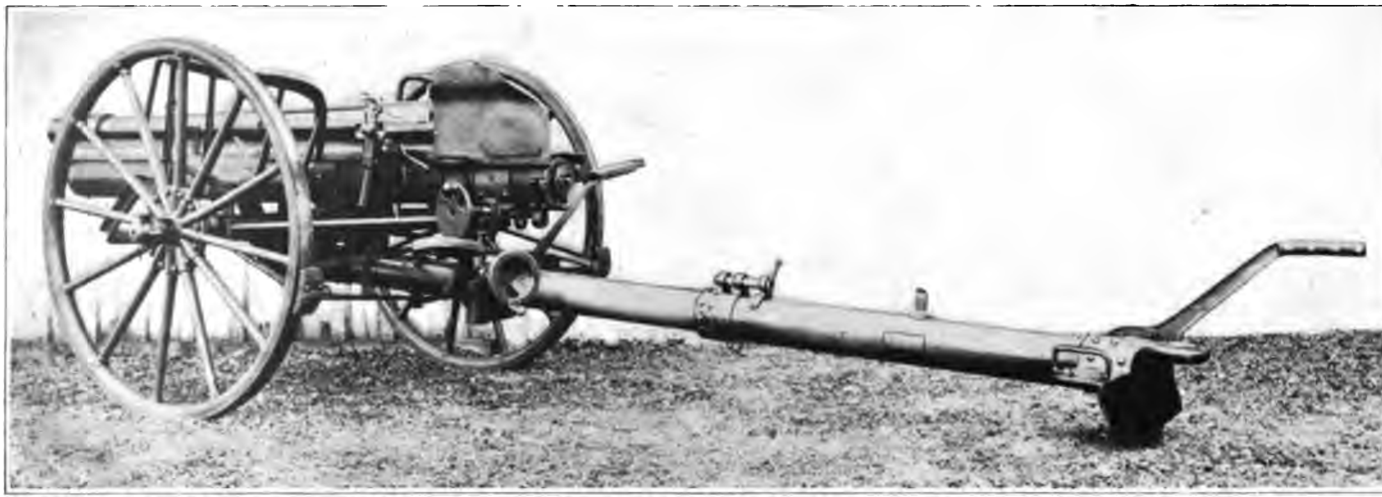
14. COCKERILL-NORDENFELT CARRIAGE LIMBERED.

Appendix IV, 1902.

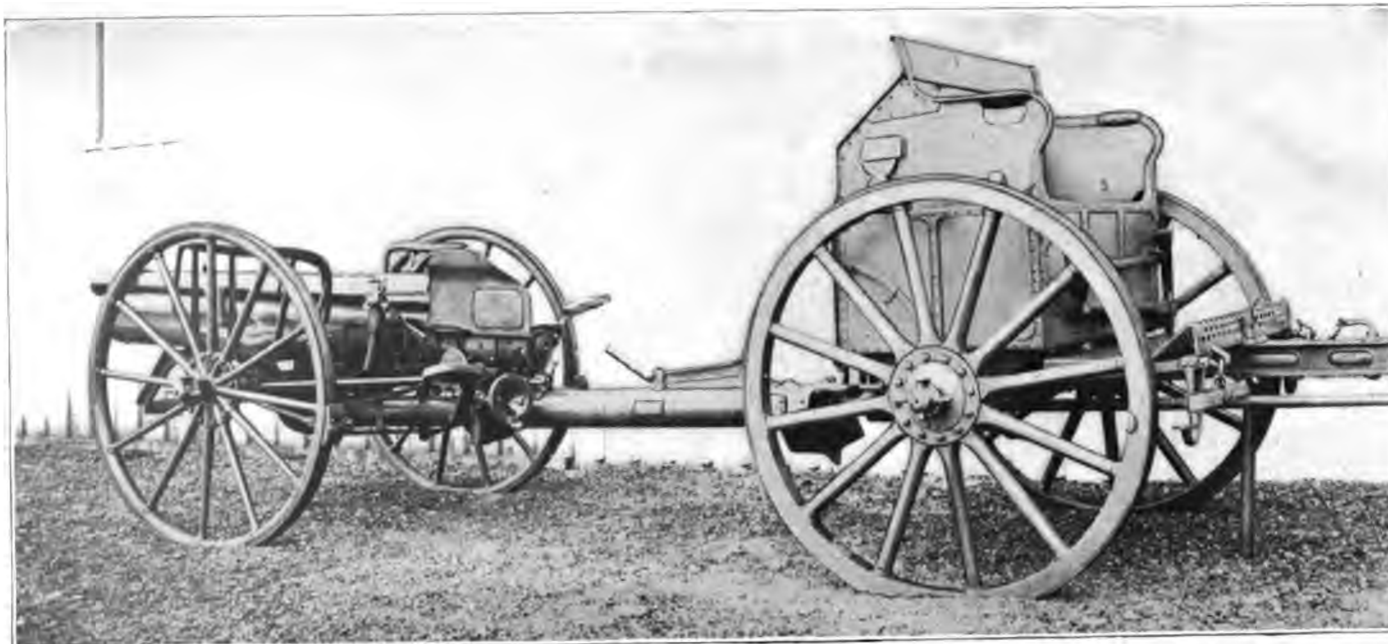


15. COCKERILL-NORDENFELT LIMBER.

16. EHRHARDT BREECH MECHANISM.



17. EHRHARDT CARRIAGE IN FIRING POSITION WITH TRAIL EXTENDED.



18. EHRHARDT CARRIAGE LIMBERED.

Appendix IV, 1902.

19. EHRHARDT LIMBER.

20. EHRHARDT CARRIAGE ON ROCK PLATFORM.

21. ORDNANCE DEPARTMENT SHORT-RECOIL BREECH MECHANISM.

22. ORDNANCE DEPARTMENT SHORT-RECOIL CARRIAGE IN FIRING POSITION.

23. ORDNANCE DEPARTMENT SHORT-RECOIL CARRIAGE LIMBERED.

Appendix IV, 1902.

24. ORDNANCE DEPARTMENT SHORT-RECOIL LIMBER.

25. ORDNANCE DEPARTMENT LONG-RECOIL BREECH MECHANISM.

Appendix IV, 1902.

26. ORDNANCE DEPARTMENT LONG-RECOIL CARRIAGE IN FIRING POSITION—REAR VIEW.

27. ORDNANCE DEPARTMENT LONG-RECOIL CARRIAGE IN FIRING POSITION—FRONT VIEW.

Appendix IV, 1902.

28. ORDNANCE DEPARTMENT LONG-RECOIL CARRIAGE LIMBERED.

Appendix IV, 1902.

29. ORDNANCE DEPARTMENT LONG-RECOIL LIMBER.

Appendix IV, 1902.

30. VICKERS-MAXIM BREECH MECHANISM.

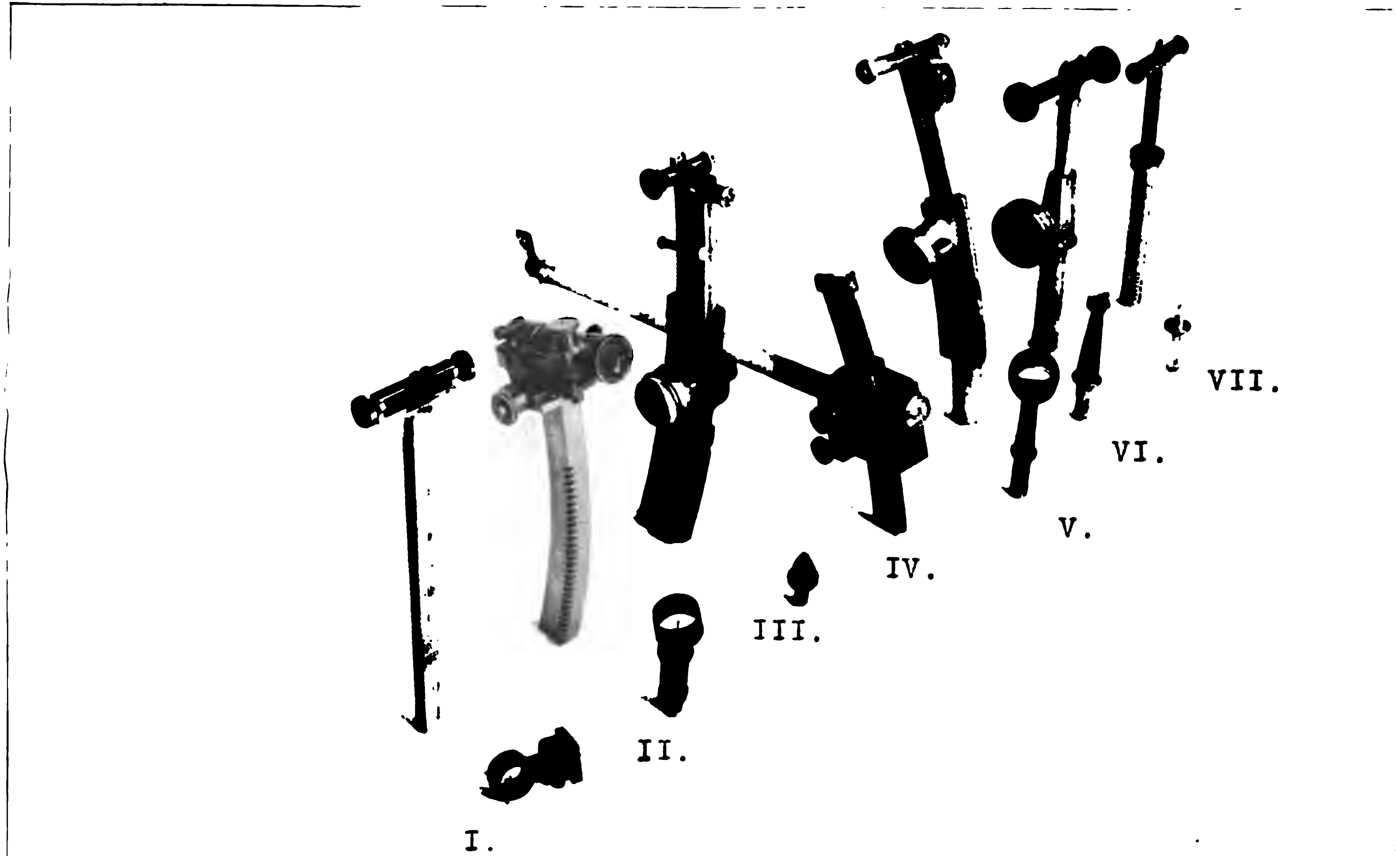
31. VICKERS-MAXIM CARRIAGE IN FIRING POSITION.

Appendix IV, 1902.

32. VICKERS-MAXIM CARRIAGE LIMBERED.

33. VICKERS-MAXIM LIMBER.

Appendix IV, 1902.



34. SIGHTS: I, ARMSTRONG; II, ORDNANCE DEPARTMENT; III, COCKERILL-NORDENFELT; IV, BETHLEHEM NO. 2; V, EHRHARDT; VI, VICKERS-MAXIM; VII. BETHLEHEM NO. 3.

APPENDIX V.

TEST OF EXPERIMENTAL SHRAPNEL FOR 3-INCH GUN.

FRANKFORD ARSENAL,
Philadelphia, Pa., November 24, 1902.

SIR: In compliance with instructions contained in O.O. letter No. 20210, dated November 17, 1902, I have the honor to submit the following report upon the experiments and investigations made at this arsenal to determine the best form of construction for shrapnel. These experiments have been of a brilliant character, and have resulted in the production of a shrapnel embodying many original features and far superior, it is thought, to any in use in this or any foreign service. The scope and results of these investigations are clearly described in the following extracts from a report of Capt. B. W. Dunn, Ordnance Department, to whom belongs the credit of inaugurating these experiments and of carrying them to a satisfactory conclusion:

Excepting the Hotchkiss Company, in France, which still manufactures a head-charge shrapnel with cast-iron separators, the universal preference abroad is for the base-charge shrapnel with a resin matrix to protect the lead balls from deformation by the shock of discharge. In England the bursting charge is small, 1.6 ounces, and the balls and matrix are assembled in a perforated tin cylinder placed in the drawn-steel case. In Germany the latest models contain about 3 ounces of powder, no lining for the case is used, and with the resin matrix is mixed a smoke-producing compound. All steel cases are drawn with increased thickness of walls around the powder chamber, which terminates in a shoulder on which rests an arched steel diaphragm to support the balls and protect the powder charge.

Our present service 3-inch shrapnel contains two features thought to be in advance of the latest European model—steel-jacketed balls and a steel case with hexagonal interior cross section.

The principal objects in view in the tests herein reported were the relative advantages of (1) head and base charge, and (2) lead balls with resin matrix in a circular case or steel-jacketed balls without matrix in a hexagonal case.

HEAD AND BASE CHARGE.

From reliable information of the results obtained abroad the preference for a base charge was pronounced at this arsenal before undertaking these tests.

The principal disadvantage of the head charge is that the shrapnel case is required to meet two conflicting conditions; it must be strong while in the gun to prevent prematures, and it must be weak during flight to insure the complete opening of the case and the liberation of all the balls at the point of burst.

All head-charge shrapnel on the separator plan manufactured in this country have failed, more or less, to meet one or the other of these conditions. The difficulty is very much increased when the shrapnel is required for fixed ammunition. In this case a support for the band other than that given by the walls of the case is necessary, and the solid separators used for the purpose are so firmly locked in the case by band pressure that they are liable to imprison all balls and separators below them.

Our service 3-inch shrapnel has met the two conditions in the field gun, but it fails to meet them in the 3-inch R. F. gun. The tangential stress on the case, due to rotation of the shrapnel, is for the latter gun more than twice that of the former.

Another important disadvantage of the head-charge shrapnel is that the terminal velocity of the bullets is decreased by the bursting charge.

The natural angle of the cone of dispersion of the bullets, as fixed by the velocities of rotation and translation, is considerably increased by the head charge.

This was thought at one time to be an advantage, since the shrapnel is generally used against troops in open order. The general increase in the velocity of shrapnel and the unavoidable variations in the burning of time fuses, however, make it impossible to accurately control the point of burst; and, assuming that for a given range the shrapnel is liable to burst anywhere within a space of 150 yards in length, it is found that the best average results are obtained with small cones of dispersion.

The principal advantages of the base-charge form are: (1) The case is required to be strong both in the gun and at the point of burst, where it is desired that the case remain intact in order to furnish a path for the powder gases to work over and increase the terminal velocity of the bullets; (2) the diaphragm separating the bullets from the powder gives the band support required for fixed ammunition; (3) the cone of dispersion is decreased; (4) the velocity of the bullets is increased about 200 feet per second, the difference in this velocity for head and base charge being in some cases more than 250 feet per second.

The disadvantage has been in securing a light diaphragm that will support the balls on discharge. Diaphragms of the thickness used in English shrapnel, and made of the best special grades of steel that the Midvale and Bethlehem steel companies could furnish, were fired, and on recovery from the sand bank were found to be dished downward.

This has been overcome here by the novel arrangement to be described later.

RESIN MATRIX AND STEEL JACKETS FOR BULLETS.

The resin matrix and the steel jackets perform the same functions on discharge—they protect the lead balls from deformation. The matrix, however, requires the assistance of the tangential strength of the case to prevent upsetting, while the steel jackets do not.

The resin is much cheaper, its cost being comparatively nothing, while that of the jackets is about 25 cents per shrapnel.

The cone of dispersion is slightly less—i. e., better—with the matrix the resin tending to hold the bullets together and preventing the free entrance of powder gases into the spaces between the bullets to spread them laterally.

From the fact that the difference between the number of bullets counted on the pattern target and the total number in the shrapnel is greater with the matrix than with the jackets, it is concluded that the matrix prevents a complete separation of the bullets.

The data presented by the pattern tests submitted herewith show that the penetration of the lead bullets used with matrix is less than that of the steel-jacketed bullets.

An important disadvantage of the resin matrix is its strong adhesion to the steel case, which offers a resistance of 6,000 to 8,000 pounds to longitudinal movement, an initial resistance to the powder charge which, as the experiments here have shown, will cause rupture of the case. Under the same conditions the case loaded with steel-jacketed balls without matrix does not rupture. When the case ruptures, the increase in velocity of balls is comparatively small, as should be expected.

The initial resistance to motion of the mass of bullets has to be carefully guarded. It is for this reason that the head of the English shrapnel is pinned instead of screwed on. The increased tamping effect of the atmosphere even may cause a case with full velocity to break when it does not break with a lower velocity. An aluminum head can be screwed on where a cast-iron or steel head of the same dimensions would have to be pinned to prevent rupture of case. The larger the powder charge the more tendency to rupture. A small charge can thus produce a better effect than a larger one. This fact is assumed to have influenced the English, who use about one-half the charge used in German shrapnel.

It is possible that the Germans may have overcome the liability of the case to break when a large bursting charge is used in connection with a resin matrix. If so, the advantage of the steel jackets will be reduced to the one item of increased penetration, which is not considered of sufficient value to justify the extra cost. Without steel-jacketed balls, the hexagonal steel case, which is slightly more expensive than the round one, will not be needed, the adhesion of resin to the balls and to the case being sufficient to prevent any relative rotation between the two.

A recommendation, then, as to the continued use of steel jackets and the hexagonal case is withheld for a final report after tests of the Ehrhardt shrapnel.

We have on hand, or contracted for, steel-jacketed balls and hexagon cases sufficient for 25,000 3-inch shrapnel, and recommendations for the model of shrapnel to be made from this material will be made after briefly describing the experimental models fired and the results obtained from them.

DESCRIPTION OF MODELS.

(See accompanying drawings.)

Experimental model No. 1.—This illustrates the present English model in the size of bursting charge and the method of attaching head. They use a heavier ball than ours (35 instead of 41 to the pound) and a heavier case.

Experimental model No. 2a.—In this the bursting charge is increased to 3¼ ounces, according to the German practice. In all our models using a cast-iron head, the head is pinned instead of screwed on, since experiments in the bombproof showed that even at rest, without any of the tamping effect of atmospheric resistance, the cases with screwed-on heads break up.

No matrix was used in this model.

Experimental models Nos. 2b and 2c.—A resin matrix was added to model No. 2 to determine its influence. For model 2c a resin matrix was used with lead balls.

Experimental model No. 3.—Recognizing the advantage of the base charge, and the impossibility of securing it in the usual way in the cases on hand, which were drawn without a base powder chamber or shoulder for support of a diaphragm, a spider diaphragm steel casting was devised, and to avoid danger of prematures from friction of powder grains over the irregular surfaces of the spider legs the powder was compressed into the six triangular prism spaces, leaving a cylindrical space in the center to hold fine-grain powder to act as an igniting charge.

In compressing the powder tapered pins were placed at the bottoms of the cavities and afterwards drawn out, thus securing an increased igniting surface to overcome what was feared would be an objectionable slowness of burning of the compressed powder.

Experimental model No. 4.—The success attending the compression of powder in the spider diaphragm led to the next step.

In model No. 4 the entire charge of 3¼ ounces is compressed, using the shrapnel case as a mold, and applying a total pressure of 60 tons, or about twice as much as the charge receives in imparting acceleration to the mass of bullets resting on it.

If no relative motion takes place among the particles of the charge there will be no friction or heat developed, and there will be no danger of a premature explosion. No relative motion can take place, because the powder has already been subjected to a pressure twice as great as it receives in service.

After compression all particles of loose powder are removed, and the upper surface of the compressed charge, as well as the adjacent steel surfaces, are covered with a coat of shellac or other protecting paint. A thin-steel disk to distribute the pressure from the balls is all that is now needed to replace the comparatively heavy diaphragm needed to protect the loose-powder charge. The cylindrical space in the center contains the igniting charge of loose powder.

Experimental model No. 5.—This differs from the preceding model only in the head, a light aluminum alloy casting being substituted for the cast iron in order to add another layer of balls. This head can be screwed on, which is a preferable mode of attachment to the pins, without increasing the initial resistance enough to cause the case to break up.

MODELS OF MOUNTAIN SHRAPNEL.

These differ from the models already referred to in the matter of weight.

The drawing of model No. 8 shows the supporting hexagonal ring that is necessary to make our present head-charge shrapnel available for use with fixed ammunition.

TABLE No. 1.—*Results of firing tests of 15-pound shrapnel.*

[Full charge, 1,750 feet per second.]

Model.	Did case break up? Yes or no.	Average penetration in white pine.	Diameter of bullet-pattern circle.	Number of pattern tests (for reference).	Maximum pressure.	Distinguishing features.
		Inches.	*Feet.*			
Service	Yes	8.33	9.25	1	31,000	Head charge.
No. 1	No	8.75	7.8	2	33,000	1¼-ounce charge, loose.
No. 2a	Yes	9.36	7.75	12	32,000	3¼-ounce charge, loose.
No. 2b	....do	9.63	7.8	4	32,000	3¼-ounce charge, loose. Resin matrix and steel-jacketed balls.
No. 2c	....do	7.61	6.75	3	30,000	3¼-ounce charge, loose. Resin matrix and lead balls.
Do	....do	6.65	7	6	32,000	Do.
No. 5	....do	8.84	7.9	5	31,000	3¼-ounce charge, compressed.
Do	No	9.11	7.75	10	27,000	Do.
Do	....do	9.7	7.75	9	29,000	Do.

When the firing recorded in Table No. 1 was done there were no facilities for measuring the velocity of the bullets after bursting of the shrapnel. This measurement was made in subsequent firings. The average penetration in white pine was obtained by placing in front of the pattern target a number of dressed pine boards, tacked together without spaces between them. The presence of knots in the boards interfered somewhat with the uniformity of the data. The steel jackets were broken and stripped when they struck these knots. All pattern tests are numbered, and the reference numbers in Table No. 1 will permit ready examination of the pattern made by any of the models.

The pattern made when the case does not break up is very regular and characteristic. A clear space in the center contains the three main fragments—head, case, and diaphragm.

The circles on patterns were drawn by hand to cover the space over which the spread of the bullets is practically uniform, and their diameters are taken to measure the effective dispersion. It will be noticed that the two shrapnel containing lead balls in a resin matrix give lower penetration and smaller pattern circles. Of the three compressed charges, one broke up the case, and for this shot the penetration falls off.

This breaking shows that the initial resistance to motion of bullets, plus atmospheric tamping for full velocity, is almost sufficient to cause even the slow-burning compressed charge to develop a destructive pressure.

There was no tendency of these shrapnel to break when the velocity was reduced to 1,360 feet per second.

TABLE No. 2.—*Fifteen-pound shrapnel.*

[Reduced charge, 1,365 feet per second.]

Model.	Did case break up? Yes or no.	Measured velocity of bullets after burst.	Average penetration in white pine.	Diameter of bullet-pattern circle.	Number of pattern test (for reference).	Maximum pressure.	Distinguishing features of model.
		Feet.	*Inches.*	*Feet.*		*Pounds.*	
Service	Yes	1,315	5.2	8.98	42	16,000	Head charge.
No. 2a	No	1,598	8.57	8.03	44	16,666	Base charge, 3¼ ounces loose.
No. 2b	Yes	1,450	6.19	7.95	45	16,633	Base charge, 3¼ ounces loose. Resin matrix, steel-jacketed balls.
No. 2c	...do	1,480	5.94	7.25	46	17,666	Base charge, 3¼ ounces loose. Resin matrix, lead balls.
No. 3	No	1,479	6.5	7.78	47	15,166	Base charge, spider diaphragm. 2¾ ounces.
No. 5	...do	1,517	6.23	7.79	39	15,660	Base charge, 3¼ ounces compressed.
Do	...do	1,579	8.3	7.78	43	16,660	Do.
Do	...do	1,598	7	7.8	48	....	Do.

[Reduced charge, 1,448 feet per second.]

Model.	Did case break up? Yes or no.	Measured velocity of bullets after burst.	Average penetration in white pine.	Diameter of bullet-pattern circle.	Number of pattern test (for reference).	Maximum pressure.	Distinguishing features of model.
Service	Yes	1,421	6.66	8.7	32	18,833	Head charge.
No. 5	No	1,601	8.2	7.78	33	16,500	Base charge, 3¼ ounces compressed.

Table 2 shows up very plainly the advantage of the base over the head charge, and of the case that does not break up over that which does.

In some cases the average penetration does not check well with the measured velocity of bullets. As in Table 1, the lead balls and resin matrix combination gives the least penetration and dispersion.

All cases containing the resin matrix broke up.

A number of tests were made of 12½-pound shrapnel in 3-inch Hotchkiss and 75-mm. Vickers-Maxim mountain guns. They show, as in the preceding tables, the advantage of the base charge in the increased velocity of the bullets.

UTILIZATION OF SHRAPNEL MATERIAL ON HAND.

For some time doubt existed as to the strength of the hexagonal steel cases obtained to execute an order for 25,000 15-pound shrapnel for the 3-inch field gun.

It is desired to emphasize the fact that exhaustive tests have shown that this doubt was not well founded, and in considering the question of utilizing any of this material for mountain-gun shrapnel it should be clearly understood that there are no defects in the cases that require this substitution.

The cases are long enough and strong enough for 15-pound field shrapnel, and if they are converted into mountain-gun shrapnel, the portion of the case cut off, as well as the labor expended in cutting it, will be lost.

The suspension of work on these shrapnel, due to the doubt above referred to, has been of great benefit to the Department in this way. Except for it the entire order for 25,000 head-charge separate-loading shrapnel would have been executed in advance of the final decision as to the use of fixed ammunition. None of these would have been available for use in the 15-pounder R. F. gun.

When the manufacturers were authorized to resume work, they were requested to draw the remaining cases (about 13,000) with the rounded corners, shown on drawing of model No. 5. They agreed to do so, and this, combined with the success of the compressed-powder charge, will enable us to furnish under this order about 13,000 shrapnel (base charge) available for use in either the 3-inch field or the 3-inch R. F. gun. Even if separate loading should be adopted for the field gun, this would not interfere with the use of the shrapnel in it.

It seems desirable to secure a supply of shrapnel available for the 15-pounder R. F. gun, since these guns are already in service. The contractor's shrapnel have not proved acceptable, and even if they finally be accepted their design is very inferior.

The cases with weakening grooves are not so suitable for base-charge shrapnel as the round-corner cases, but comparison of the pattern tests of head-charge shrapnel and base-charge shrapnel (both with grooved cases and altered band seats) shows that even when the grooved case breaks up it gives better results with the base than with the head charge.

While these experiments of Captain Dunn's did not decidedly determine the relative advantages of the hexagonal case and jacketed balls and the round case and resin matrix, they showed unmistakably the advantage of the base charge over the head charge, and the original and peculiar form of the former marks a decided step in the development of this class of projectiles.

At the conclusion of these experiments the status of work on the 12,000 hexagonal cases with sharp corners, referred to in the above report, was as follows: 4,500 had been made up, as originally ordered, into head-charge separate-loading shrapnel for the 3-inch field gun, and 7,500 had been grooved and partly machined. The results of the experiments were so conclusive that at once orders were received to make up the 7,500 sharp-cornered cases into 12½-pound base-charge shrapnel for the 75mm. Vickers-Maxim mountain gun according to model 6; and later, in view of the urgent need of shrapnel for this gun, orders were received for the alteration of the 4,500 head-charge separate-loading 3-inch shrapnel into shrapnel of the same kind.

This has been the principal work in the shrapnel department during the past year. About 10,000 have been finished and tested at this arsenal. The tests have been most satisfactory, fully substantiating all that Captain Dunn claims for this form of shrapnel. The average velocity of the bullets at the point of burst was 1,040 feet per second, 120 feet more than the velocity of the shrapnel just before burst; the diameter of the maximum bullet pattern circle was 9.75 feet, that of the minimum bullet pattern circle 7.8 feet; the average penetration in white pine was 3.95 inches. These results, satisfactory as they are, would have been materially better but for the fact that in turning down these cases (originally designed for 15-pound 3-inch head-charge shrapnel) to adapt them for the 12½-pound 75mm. shrapnel they were so weakened that they frequently failed to remain intact at the point of burst, thus increasing the cone of dispersion and lowering the terminal velocities of the bullets.

Pending the selection of a type field gun and carriage, and the conclusion of experiments to develop a satisfactory time fuse for the 15-pounder R. F. gun, nothing has been done toward converting the 13,000 cases with round corners referred to in the above report into 15-pound 3-inch shrapnel, except to make a few experimental lots from time to time for use in guns undergoing trial.

FURTHER INVESTIGATIONS.

While the universal preference abroad is for the base-charge shrapnel with a resin matrix to protect the lead balls from deformation by the shock of discharge, the use of such a matrix in the above experiments gave results, owing to its strong adhesion to the case, inferior to those obtained with the steel-jacketed balls without a matrix.

One of the advantages of a matrix would be to reduce the cost of our shrapnel by enabling hardened lead balls and round cases to be used in place of the steel-jacketed balls and hexagonal cases, but the disadvantages of a resin matrix as disclosed in the experiments more than counterbalance the advantages. The object, therefore, of these further investigations has been to find a matrix that would satisfy the conditions of protecting the lead balls from deformation, of not adhering too firmly to the case, and, what is equally important, of producing a large quantity of smoke after burst.

This work, however, is yet in the experimental stage, but the results thus far obtained with 75mm. 3-inch and 6-inch shrapnel are very promising.

Very respectfully,

FRANK HEATH,
Major, Ordnance Department, U. S. A., Commanding.

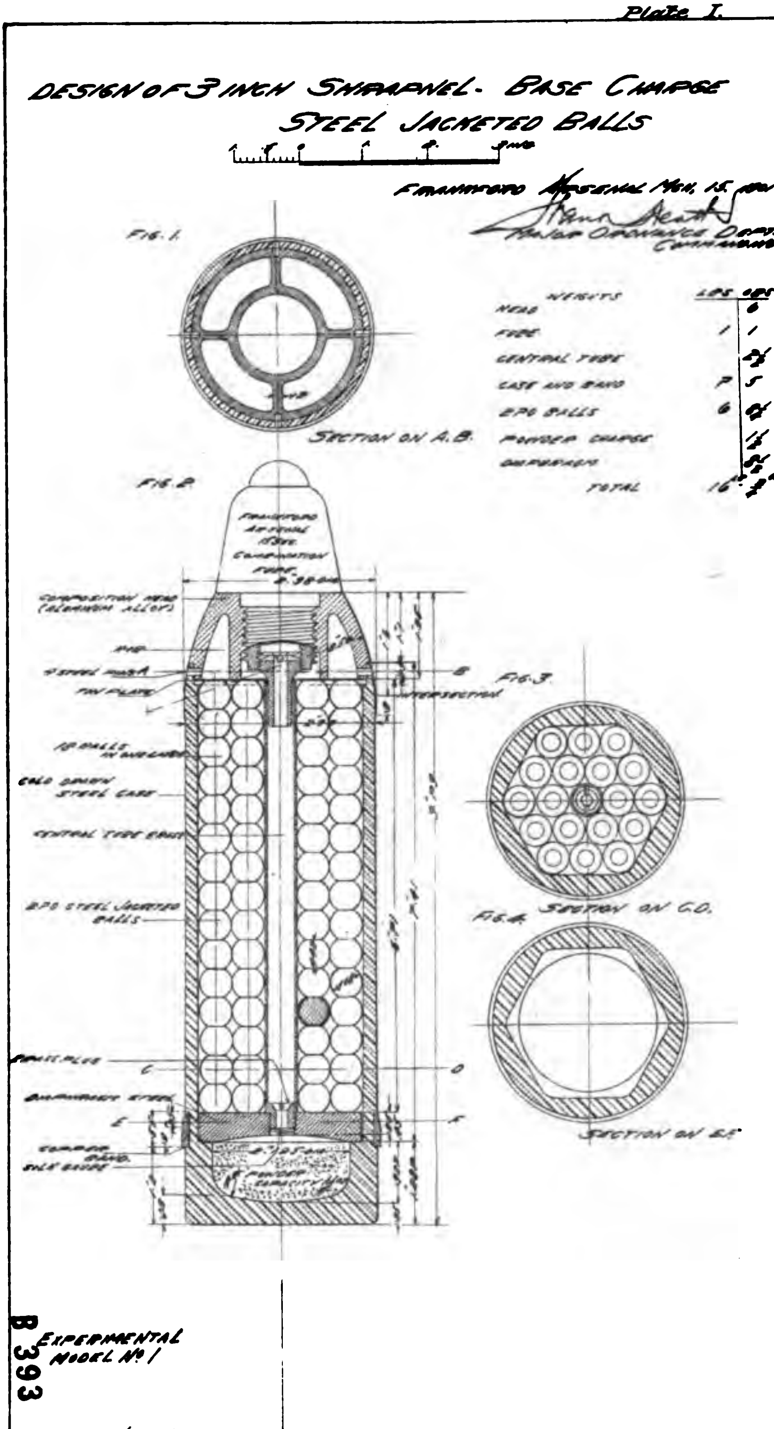
The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

Inclosures:

Eight tracings of experimental models, Nos. 1 to 8, inclusive.

Pattern tests Nos. 1 and 10 only are published, as these show the characteristic differences between the patterns made with head-charge shrapnel and with shrapnel with base charge of compressed powder.

20210—182.



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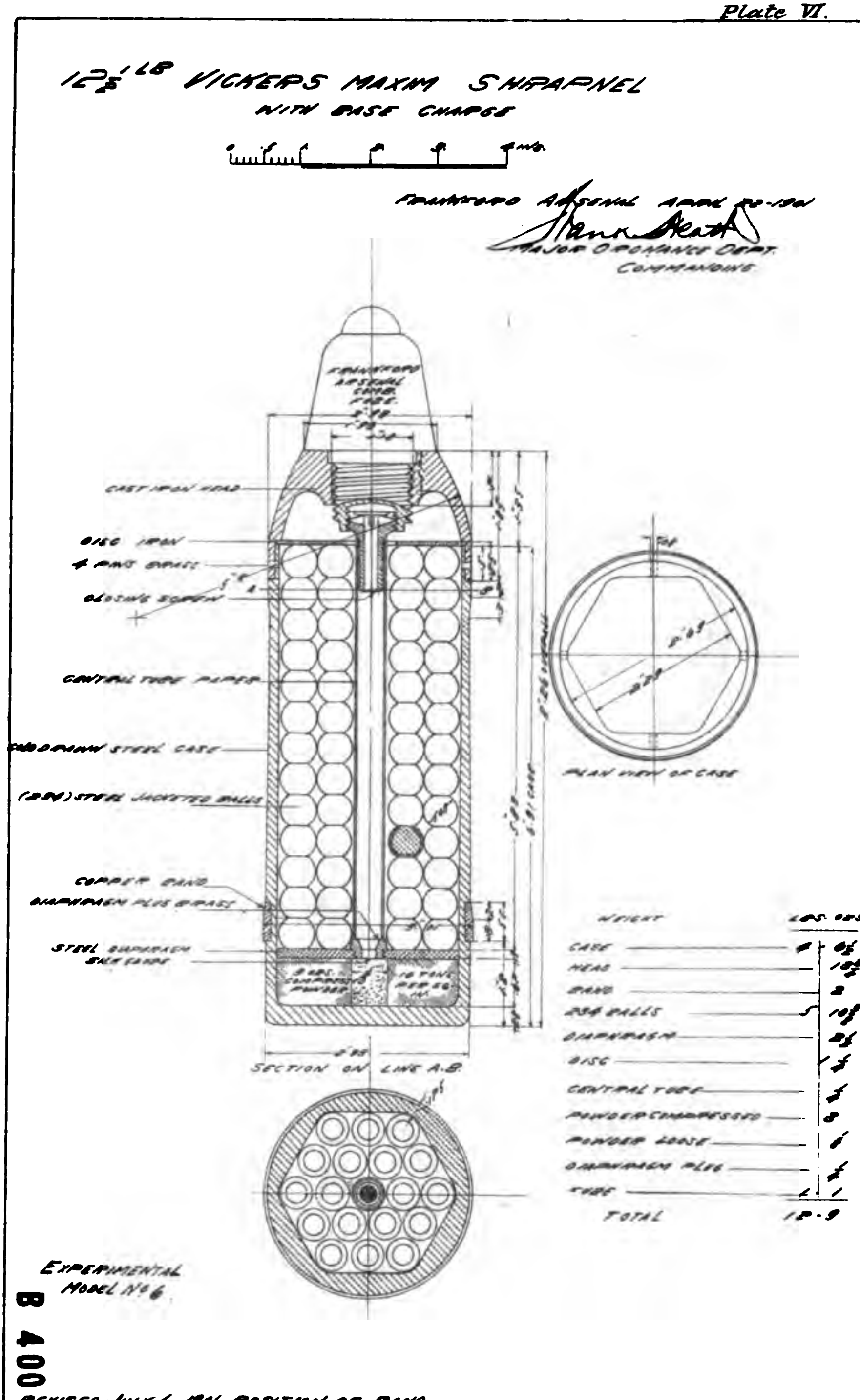
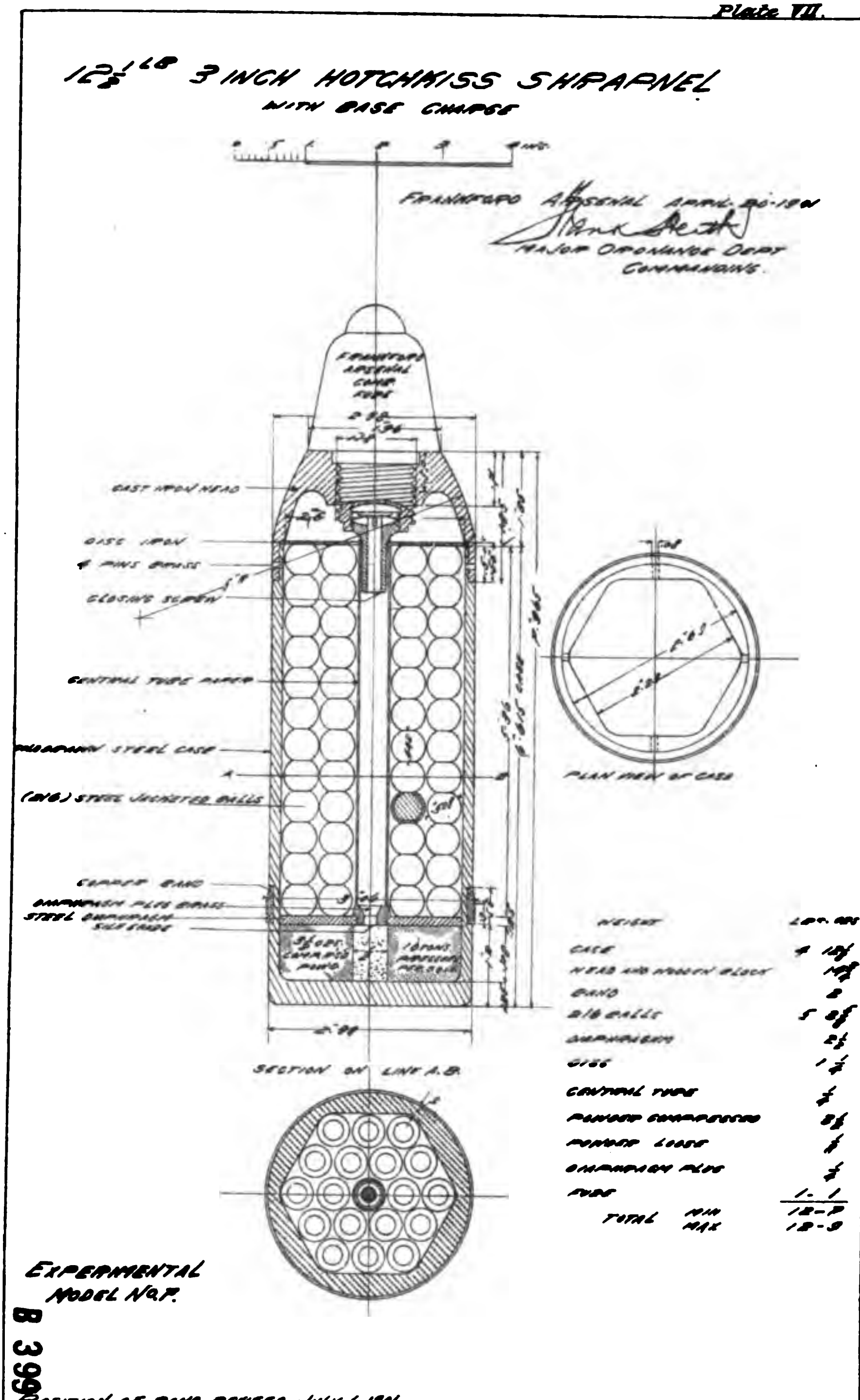
Appendix V, 1902



Appendix V, 1902.

Ord 57 2



Appendix V, 1902.

PATTERN TEST OF *Frankford Arse*

FRANKFORD

No. of test,........

Head Charge shrapnel *F.A.* drawing......

Weight *15* ...... lbs.

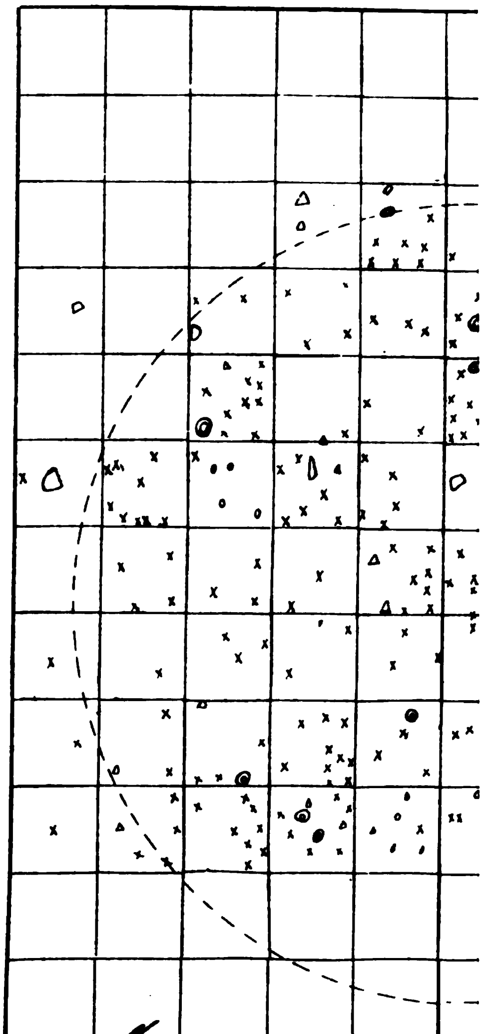
Distance point of burst from target *50* feet.

No. of bullets in shrapnel *285*

" " struck target *250*

" fragments struck target *49*

Initial velocity *1720* f. s. *(estimated)*

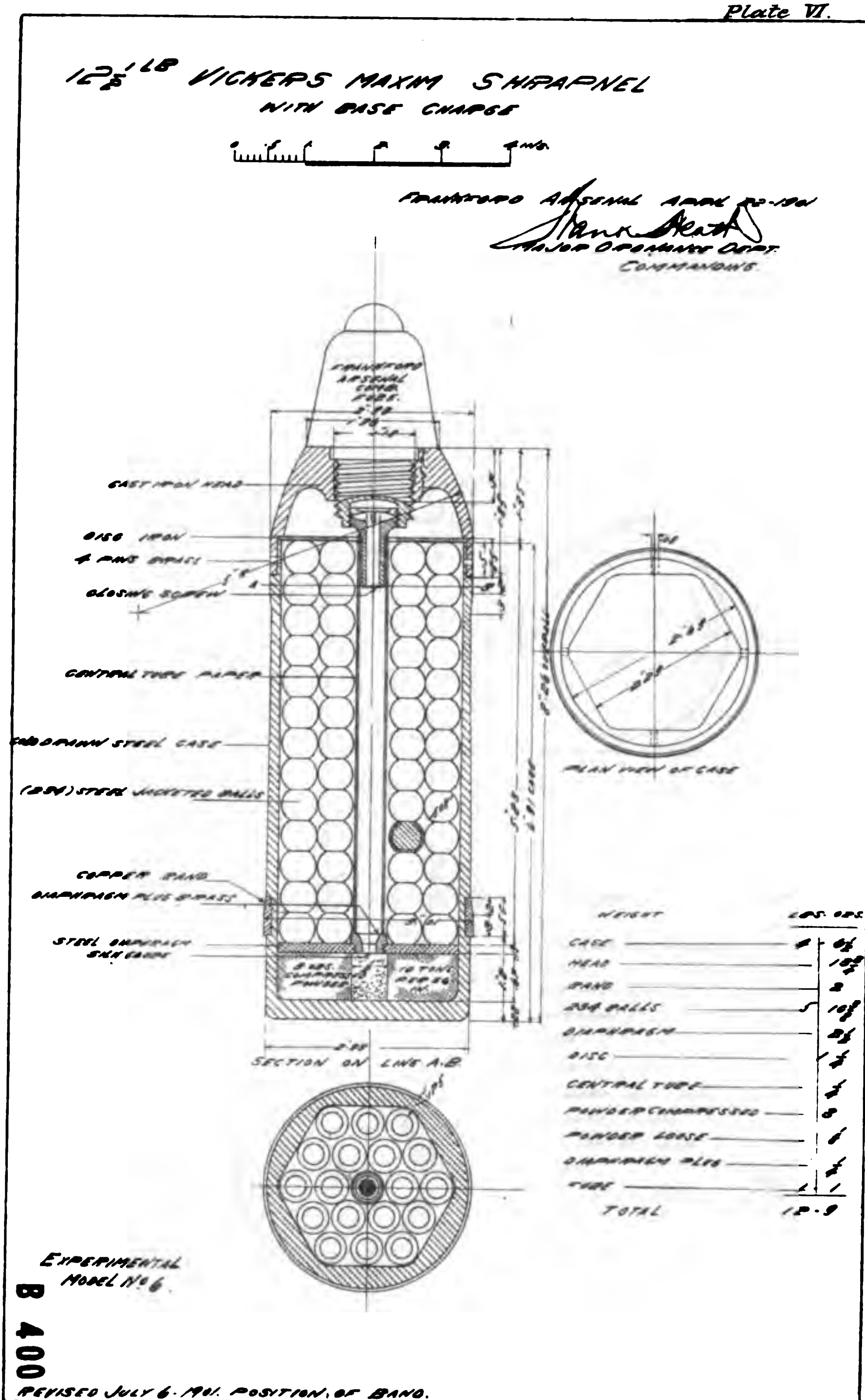


Frank Heath

Major Ordnance Dep't, U. S. A.,
Commanding.

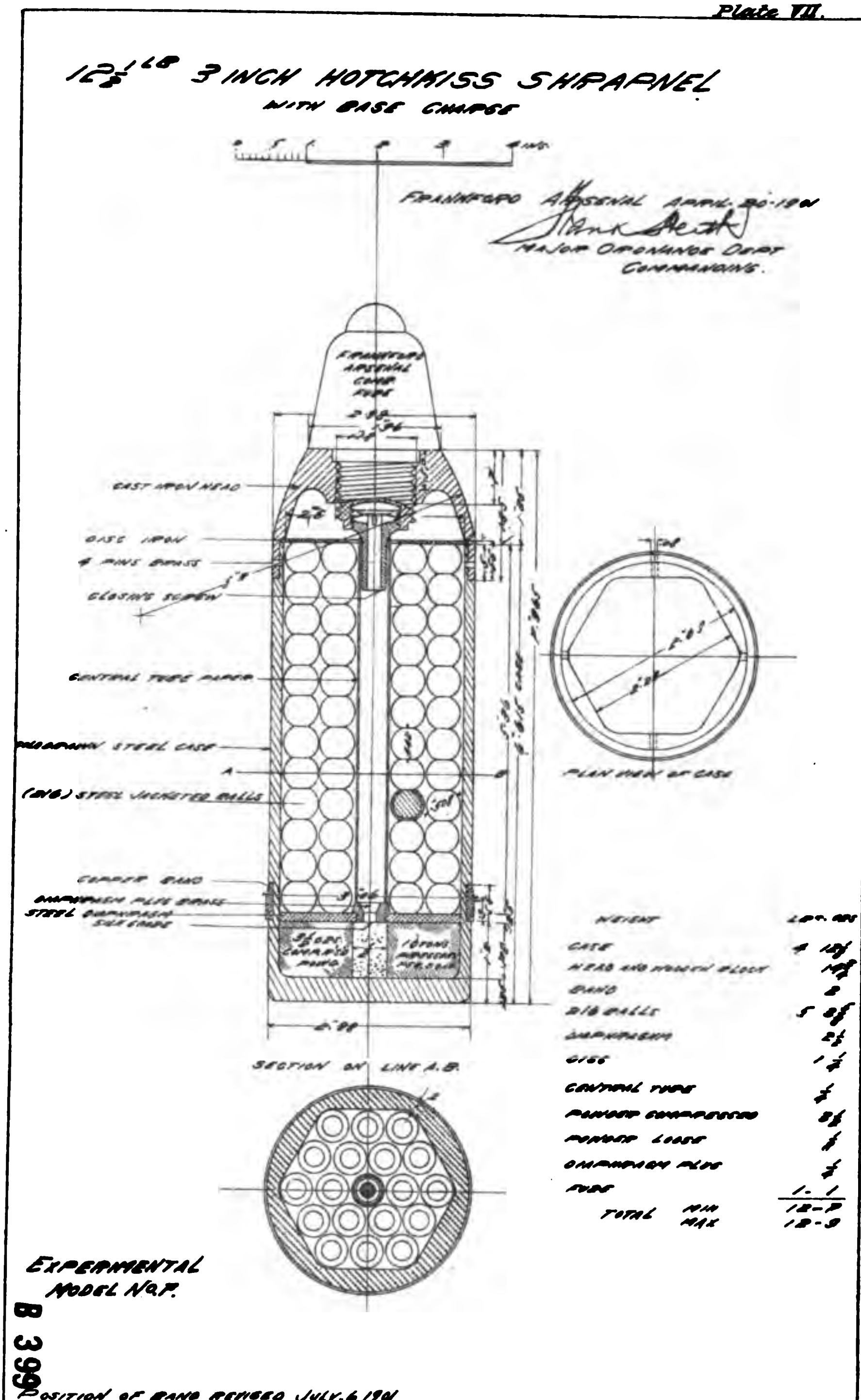
Appendix V, 1902

Plate VI.



Appendix V. 1902.

Ord 57 2



Appendix V, 1902.

Ord 57 2

PATTERN TEST OF Frankford Arse[nal]

FRANKFORD

No. of test..............................

Head .. Charge shrapnel G A ... drawing............

Weight ...15............lbs.

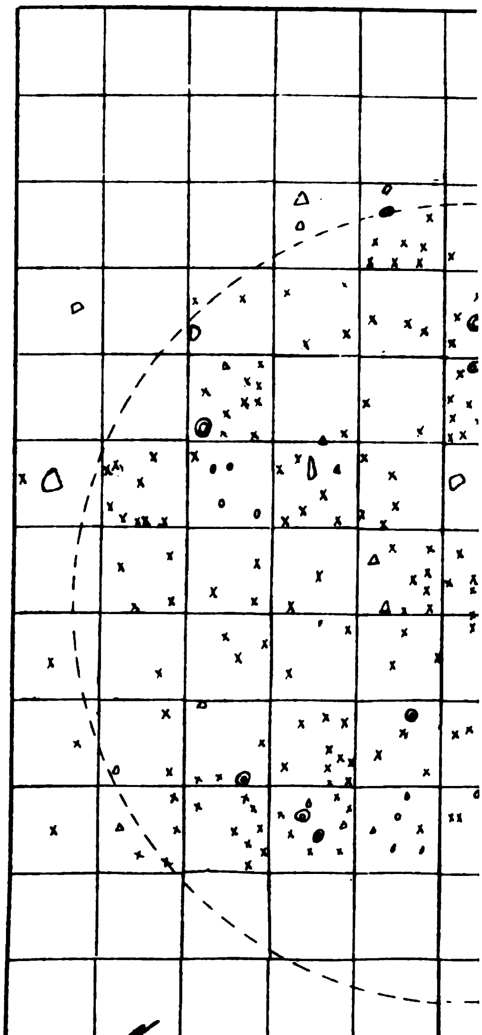
Distance point of burst from target ..50 ....feet.

No. of bullets in shrapnel 285 ..

" " " struck target 250

" fragments struck target 49

Initial velocity. 1720 f. s. (estimated)



Frank Heath

Major Ordnance Dep't, U. S. A.,
Commanding.

Appendix V, 1902

PATTERN TEST OF F.A. E...

FRANK...

No. of test 10

2½ ... Comp's (40 ...) Base Charge shrapnel F.A. drawing 4/20...

Weight 15 lbs.

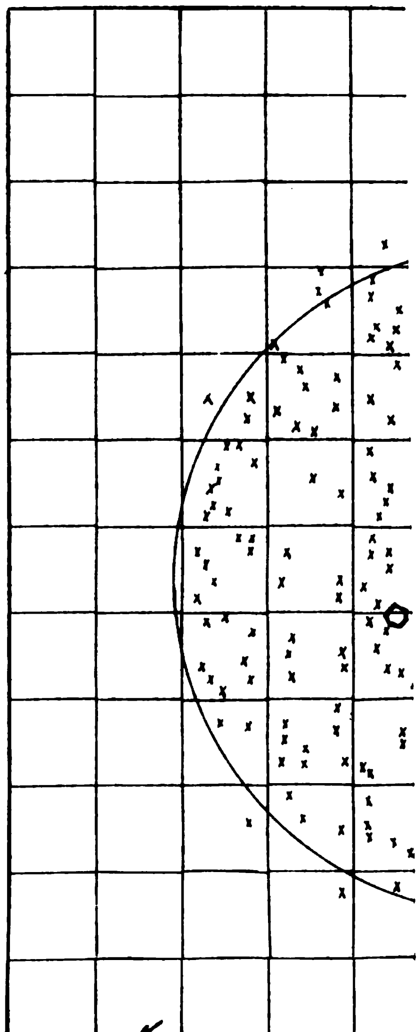
Distance point of burst from target 47 feet.

No. of bullets in shrapnel 288

" " " struck target 288

" " fragments struck target 4

Initial velocity 1750 f. s. (est.)



Major Ordnance Dep't, U. S. A., Commanding.

Appendix V, 1902.

APPENDIX VI.

TEST OF BASE PERCUSSION FUSE FOR FIELD, SIEGE, AND SEACOAST SERVICE.

THE ORDNANCE BOARD, U. S. A.,
NEW YORK ARSENAL,
New York City, January 9, 1902.

SIR: The board respectfully submits herewith a report of trials made with various types of Frankford Arsenal base-percussion fuses since May, 1900, to include the matter contained in several communi cations upon the same subject, namely: May 28, 1900 (23100), December 20, 1900 (35650), January 5, 1901 (35650–Enc. 6), June 27, 1901 (35650–Enc. 11), and September 14, 1901 (35650–Enc. 15), and the firing records pertaining thereto are incorporated herewith.

The object at first sought was an improvement in the service patterns of ring-resistance fuses to include a type that would function with side impact of the projectile on water as well as on land. In the course of the trials, however, several types of centrifugal fuses were presented, and as these promised greater safety in service than the existing patterns their trials have been extended to develop a type which is now proposed to replace the ring-resistance type in service. Two designs of centrifugal fuses have been extensively tested. The one preferred is designated the revolving pin fuse from a distinctive feature of the firing pin, which lies flat in the plunger under ordinary conditions, but is revolved into the armed position by the centrifugal force due to the rotation of the projectile when fired from a rifled cannon.

The trials, in chronological order, have included the following fuses:

F. A. EXPERIMENTAL SIDE-IMPACT, BASE-PERCUSSION FUSE.

(Plate I.)

The fuse, as designed by Capt. B. W. Dunn, is shown on the copy of the original Frankford Arsenal drawing, dated October 17, 1899, herewith. This represents the large fuse W. The smaller fuses, A and C, are of similar design.

The novel features of this fuse are in the plunger, which is supported by a conical pin at the rear and a conical ring fitting over a corresponding slope at the front, so arranged that the plunger will be forced forward on impact, even though the projectile strikes on its side or within limits, when the base is inclined downward. The resistance of the fuse to arming is controlled by a spring ring on the spindle similar in design to the service fuse.

The several lots of this design of fuse received at the proving ground were tested, as follows:

Lot 1. Six side-impact W, for 12-inch B. L. mortar shell. These fuses differ from the drawing, Plate I, only in having the extra primer shield removed, drop tests at Frankford Arsenal having shown that the extra shield induced irregular action. Five were tested.

Lot 2. Twenty-five side-impact A, for 5 and 7 inch siege shell and 12-inch mortar shell tapped for A fuse. Sixteen were tested.

Lot 3. Fifty side-impact C (25 each, low and high) for field cannon. Nineteen were tested.

Lot 4. Fuse C of service pattern with primer shield 0.0015 inch thick, to test action at graze on land and water. Ten were tested.

Lot 5. Five side-impact W special, with side retention pin in plunger, and fulminate primer. All were tested.

The following conclusions are drawn from these trials:

1. Side-impact fuse W gave good action in 12-inch mortar shell at 60° elevation with low charges, causing side impact of the projectile on water.

2. Side-impact fuse A gave unsatisfactory action in 12-inch mortar shell under the same conditions; this is attributed to the relatively light weight of plunger in fuse A. This side-impact fuse gave good action in 7-inch mortar shell at 65° to 70° elevation with low charges, causing side impact of the projectile on land; but gave premature action in 5-inch siege gun with full charges.

3. Side-impact fuse C (low) gave good action in 3.6-inch mortar shell at 60° elevation with the minimum service charge on land, and the fuses of both low and high resistance acted well in 3.2-inch field shell, at zero elevation with full charges, for graze on land and water.

4. The premature action of the side impact A in 5-inch siege gun and of W in 3.2-inch field gun, although the latter is not a service condition, point to the principal defect of the design, viz: The centrifugal action due to the rotation of the shell when fired may throw the plunger out of center, and when this occurs the plunger will be forced forward prematurely by the guiding surfaces, which are intended to move it forward on side impact only. The development of this defect led to a suspension of the trials of this design of side-impact fuse.

5. In the comparative trials the A and C patterns of the service fuse (ring-resistance type) gave about equally satisfactory action with the side-impact fuses under the most trying conditions, namely: 3.6-inch mortar at high angle and minimum service charge; 7-inch mortar at high angle and reduced charges, and 3.2-inch field and 5-inch siege guns, at 0° elevation, with the projectiles striking by graze on land and water. The important conclusion drawn from this is that the side-impact feature is not a necessary adjunct of field and siege fuses, except possibly for the 7-inch mortar. At the shorter ranges which are included for the service of this mortar, as now mounted, the tendency of the projectile to fall in different positions is such that a side-impact feature is desirable in its fuse.

F. A. EXPERIMENTAL CENTRIFUGAL, BASE-PERCUSSION FUSE, M'BRIDE DESIGN.

(Plate II.)

The designs include a centrifugal fuse simply and a centrifugal fuse for side impact, of the several sizes required in service.

The centrifugal feature was designed by Matthew McBride, foreman, Frankford Arsenal.

The accompanying drawing, Frankford Arsenal, March 16, 1901, revised to August 15, 1901 (Plate II), shows the construction of the centrifugal, side-impact W fuse, and suffices to explain the construction of the remainder. The only difference between the simple centrifugal fuse and the centrifugal side-impact fuse is that the plunger in the latter is tapered to the rear and terminates in a conical projection fitting into a conical recess in the base of the fuse cavity. In the simple centrifugal fuse the plunger is cylindrical, with flat base, and conforms in diameter to the fuse cavity.

The distinctive feature of the design consists in supplying the fuse plunger with three shields fitting in longitudinal slots in the plunger 60° apart, hinged near the bottom by means of a pin journaled in the fuse body and provided at the top with flat projections which, in the unarmed position of the fuse, serve to interpose solid metal between the upper face of the plunger and the rear face of a projection of the fuse cap, thus keeping the firing pin at a safe distance from the primer.

The spiral springs (*o*), acting in a direction perpendicular to the axis of the fuse, are depended upon to keep the shields in their unarmed position. The effect of centrifugal force is to move them out, compressing the springs. When out, any retardation of the projectile moves the plunger forward, the shields encircling the projection from the fuse cap and the firing pin entering the primer recess. The spiral spring (*j*) serves to keep the plunger to the rear during the flight of the projectile. Plungers of this design can be used in the service fuse bodies, but they require special caps. The firing pin (*l*) is a separate piece forced into its cavity and held there by a pin through the plunger. (Not shown in the drawing.) The three shields are supplied to increase the safety features of the fuse, any one of them in its unarmed position being sufficient to prevent premature action.

Supposing these shields to remain in their safe position, the resistance to forward motion of the plunger, in case the fuse or projectile is dropped on its point, depends upon the resistance of the walls of the hollow projection from the rear of the fuse cap and upon the area of contact of the rear surface of this cap with the inner edges of the three shields. It is necessary to arrange this area so that with the limited outward motion of the shields there will be secured several hundredths of an inch clearance between the inner edges of the shields and the outer diameter of the fuse-cap projection, in order to allow the plunger to move forward. This condition makes it more difficult to construct, on this design, small fuses than large ones; on the other hand, the small fuses, being used in the high-power guns, can be given a higher resistance to arming, which increases their safety. A fuse of this design of the "A" size has been dropped directly on its point from a height of 30 feet without firing the primer, although the surface of contact between the fuse cap projection and the three shields showed considerable deformation. There is no unity of action of the three shields of this design, as there is in the two parts of the plunger of the revolving pin design. A side blow will cause the downward shield to be thrown outward to its armed position, but at the same time the others would be forced more securely into their unarmed position. Such a blow delivered to the revolving pin plunger would necessarily tend to close the two halves. In the same way, continued jolting of the McBride fuse on its point would deform the bearing surfaces and tend to make them conical rather than perpendicular to the axis of the fuse. In course of time this would introduce a wedge-like action, tending to open all of the shields.

The different lots of these fuses received at the proving ground were tested, as follows:

Lot 1. Twenty-five centrifugal C (tested under direction of the commanding officer of the proving ground).

Lot 2. Twenty-five centrifugal A (tested under direction of the commanding officer of the proving ground).

Sample centrifugal, side-impact fuse W; firing record February 20, 1901, 3.2-inch gun.

Lot 3. Twenty centrifugal, W, arming at 900 revolutions per minute. After 5 of these were tested in 3.2-inch field gun (February 8, 1901), with one failure and one explosion on second ricochet, the remainder were returned to the arsenal to increase the clearance of the shields; 13 in all have been tested.

Lot 4. Twenty centrifugal, side impact W, arming at 900 revolutions per minute. On arrival of these fuses at the proving ground 4 were found to have been ignited in the packing box in transport. The lot was returned to the arsenal and altered by reducing the primer orifice and giving better support to the spiral spring in front of the plunger; 15 have been tested.

Lot 5. Ten centrifugal, side impact A, arming at 900 revolutions per minute. One of these fuses was ignited in the packing box in transport from Frankford Arsenal to the proving ground; 2 have been tested.

The following lots received have not been subjected to firing tests:

November 14, 1901, 25 centrifugal A, arming at 1,500 revolutions per minute.

November 22, 1901, 20 centrifugal, side impact W, arming at 900 revolutions per minute.

December 5, 1901, 25 centrifugal C, arming at 3,000 revolutions per minute.

The following conclusions are drawn from the trials:

1. The simple centrifugal fuses, sizes C and A, gave very satisfactory results. There were no prematures in the 50 fuses fired. There were in all 5 failures to function properly, namely: 1 out of 14 against light wood screens, and 4 out of 11 fired at zero elevation from guns to burst at graze on land or water. Ten fired from guns at 2° elevation, 5 from 3.6-inch mortar, 7 from 7-inch mortar, and 3 from 12-inch mortar, all on land at 45° elevation, functioned properly.

2. The simple centrifugal fuse W gave no prematures, but the 3 fired in 12-inch mortar shell failed to explode on water, thus indicating the necessity for a side-impact arrangement in fuses intended for this service.

3. The centrifugal, side-impact fuses, sizes W and A, functioned without failure in 17 fired, except 1 doubtful explosion in 12-inch mortar shell on water.

4. However, the explosion of 4 W and 1 A centrifugal side-impact fuses in the packing boxes during transportation from Frankford Arsenal to Sandy Hook constitutes a grave defect, and indicates at least that this design is not applicable to patterns of such low arming resistance as 900 revolutions per minute. The spiral springs which restrain the outward movement of the shields in this case are too light to be fully reliable.

All the tests, including shop tests at the arsenal, show that with a resistance to arming not below 1,500 revolutions per minute this fuse should be safer than the present service (ring-resistance) type, and it might be used where the higher arming limits are permissible. But in view of the limited area of resisting metal to conserve safety, previously referred to in the description of the design, the board concluded to suspend the tests of this fuse and prosecute fully those of the second design of revolving pin fuse.

F. A. EXPERIMENTAL REVOLVING PIN, BASE PERCUSSION FUSE—FIRST DESIGN.

(Plate III.)

The design is due to Capt. B. W. Dunn, Ordnance Department, U. S. Army.

The first pattern of the fuse presented for trial is shown on the accompanying drawing, Frankford Arsenal, August 23, 1901 (Plate III).

The firing pin in its normal position is revolved so as to point away from the primer. It is assembled on a shaft, which is connected with two centrifugal nuts. The seat for the shaft being partly in the nut and partly in the fuse plunger, it is seen that the shaft acts as a key

for the nuts, to prevent their rotation as they move outward under centrifugal force. The hole in the nut forming the seat for the shaft contains square spiral grooves with a pitch of two per inch, and pins located in the shaft fit into these grooves. The spirals are right-hand in one nut and left-hand in the other. When the nuts fly out under centrifugal force the shaft is caused to revolve, this motion being limited to bringing the firing pin to a vertical position when the nuts have reached the limit of their outward motion. This motion can be produced by inserting the end of some sharp instrument under the firing pin and revolving it up to its upright position.

The three parts, the shaft and two nuts, constitute what may be termed the "arming unit," and a very essential feature of the fuse is that this unit shall have a free motion from one side of the plunger to the other. The result of this is that it is impossible by any jarring or jolting to produce any tendency of the fuse to arm. If the shaft and pin were fixed in a central position, jolting would tend to produce a motion of the nut along the shaft, which would have to be resisted by a spring or the friction of the key pin in the spiral groove. This is all avoided by the unit motion referred to.

It will also be noticed that a simultaneous tendency of the two nuts to fly outward is necessary to arm the fuse, and this can be produced by rapid rotation alone. The small spiral spring in the center of the two nuts tends to keep the fuse in an unarmed position. The fuse is safe against premature arming without this spring, and in that respect it is thought to be unique and to possess an advantage never before presented in a centrifugal fuse. The natural tendency of the pin, as the result of the force of gravity, is to stay in its unarmed position, and it requires, without the spring, by actual measurement, about 700 revolutions per minute to arm it. Jumbling tests have shown that without any spring it is impossible by any jolting or jarring to arm the fuse.

The two spring pins in the fuse cap are introduced for the purpose of keeping the plunger during flight of shell in its rear position, in order that all eccentric rotation of plunger may be prevented and that the full force of the wedge in the rear may be secured in case of side impact. They also insure that the space between the plunger and the cap shall be such that the firing pin will meet with no resistance from the cap when it revolves to its armed position.

Thirty fuses of this design, size W, were received for test. They comprised 10 with the pin shaft in the upper side of the nuts, as shown on Plate III, and 20 with this shaft in the center of the nuts. After 9 had been tested in a 3.2-inch field gun (June 25, 1901), with failure to function when fired to burst with low angle of impact on water, the remainder were returned to the arsenal and altered by lengthening the firing pin and by placing stops to limit the outward motion of the nuts. Twenty-seven in all have been tested.

The test of these fuses after the alteration was satisfactory, except in the 7-inch mortar shell fired with low charges on water. As, however, a simplification and improvement of the design was then brought out by Captain Dunn, the trials of this pattern were suspended.

SECOND DESIGN—REVOLVING PIN FUSE.

(Plates IV and V.)

The patterns include a centrifugal fuse simply and a centrifugal fuse for side impact of the several sizes required in service. They are illustrated by the accompanying drawings of the A size, viz:

Frankford Arsenal, November 6, 1901, centrifugal fuse, Plate IV.
Frankford Arsenal, November 4, 1901, centrifugal fuse, side impact, Plate V.

The fuses received at the proving ground comprised 25 C and 25 A, centrifugal, and 10 special A and 20 W, centrifugal, side impact. No change was made in the service form of fuse bodies, primers, etc., other than to decrease the diameter of the primer orifice to 0.1 inch. This was done in order to cut down the delay action of the service percussion primer.

The fuse plungers are made by connecting two pieces of brass cut from a rod, practically almost semicircular in cross section and with lugs projecting from their flat faces to fit into corresponding recesses in the opposite half of the plunger. A special form of steel spring, stamped out originally and then bent into a U shape, with a hole through the reenforced center of the spring fitting over a circular projection from the bottom of the assembled plunger, holds the two faces of the plunger in position and exerts a constant force tending to keep them closed. Through the projecting lugs from the flat faces of the plunger pieces holes are drilled to furnish journals for two steel pins (*m*). The lower one of these forms the fixed axis about which the firing pin (*k*) revolves; the upper one, working in a slot in the firing pin, serves to guide the pin and steady it in its armed position. The opening of the plunger is limited by the contact of the firing pin with one of the sides in its armed position. It is necessary that the shell should have a more rapid revolution than that required to arm the fuse. An excess in rotation of from 50 to 100 revolutions per minute is sufficient for this purpose. The sides of the plunger are not permitted to bind against the interior surface of the fuse stock, as this would create frictional resistance to the forward motion of the plunger on impact.

The drawings show a holdback spring and plunger (*g*) inserted as an experimental feature. It is intended to keep the plunger in contact with the rear surface of fuse cavity, giving freedom for the firing pin to rotate to its armed position; also to keep the firing pin away from the primer shield during the flight of the projectile, and secure the maximum path for travel of the plunger on impact of the shell. Inasmuch as the resistance of the spring in this holdback must be overcome, the device is considered of doubtful utility. At the time that the fuse arms, the acceleration of the projectile will insure the contact of the plunger with the rear of the cavity, and the pin will revolve into its armed position before any creeping forward of the plunger can take place due to atmospheric retardation.

The side impact feature, Plate V, consits in tapering the plunger to the rear and inserting a side impact wedge (*q*), fitting into a conical recess in the fuse body. On side impact of the shell this acts to force the plunger forward and explode the primer even if the shell falls with its base downward, provided the angle of inclination to the rear is considerably less than 45°.

This side impact device is the successor of that shown on Plate I, and is not liable to cause premature explosion during flight of the projectile. This improved device was also applied successfully to the McBride fuse, Plate II. The upper end of the armed plunger is of normal diameter and the lower end is centered by the wedge. Under these circumstances no eccentric rotation of the plunger can take place.

The following safety features of the design are thought to be of special value:

1. The natural tendency of the two faces of the plunger is to remain in the closed position, even without the assistance of the U-shaped spring. No jolting of the fuse can cause them to open.
2. While in the closed position there is no possibility for a premature explosion, since the firing pin is not directed toward the primer; no matter in what direction the fuse be dropped, there is plenty of solid metal to receive the blow.
3. Even if, in some unforeseen way, the fuse should be armed, it must, at the same instant, be dropped on its point or side to cause explosion, the natural tendency of the plunger being to close and return to its unarmed position.

During the construction of the fuse, it was suggested that possibly it might be advantageous to furnish some locking device which would cause the fuse when armed to remain armed. A simple device of this nature not shown in the drawing was furnished with some of the fuses sent to the proving ground. It also requires centrifugal force for its operation. The fuses supplied with it are marked on the base with the letter I. All of the fuses, excepting those of the C pattern, were supplied with the holdback spring so that in the test this spring could be removed or not, in order to determine its value.

The fuse is not armed by the shock of discharge in the gun, which, by creating pressure on the base of the plunger, effectually maintains the two faces in the closed position, and the arming is retarded until the force of acceleration in the direction of the longer axis has been overcome by the centrifugal force due to rotation, tending to open the sides. This will not occur until the projectile has passed out of the bore, and this removes all chances for a premature explosion in the bore due to the percussion fuse.

In tests made at Frankford Arsenal it was found that with the low rate of arming of 900 revolutions per minute it was impossible by rolling the A fuze down a 45° slope to reach a sufficient angular velocity under the action of gravity to arm the fuse when the perpendicular height through which it was rolled was 6 or 8 feet. In the 12-inch projectile this vertical height would have to be at least 72 feet, and it would then be necessary for the shell to roll without obstruction in a right line down this slope. The rotating band would cause it in a short time, if rolled on a concrete ramp, to turn base first, and would thus prevent the projectile from acquiring its maximum revolution. When the holdback spring was left out it was not found possible to arm the side impact fuse, even when rolled down a slope from a perpendicular height of 13 feet. This was due to the forward motion of the plunger, so that its front face rested against the fuse cap, and this offered a resistance to the rotation of the firing pin. The resistance to arming is higher in all nonside impact fuses.

The different lots of these fuses were tested at the proving ground, as follows:

Lot 1. Ten centrifugal, side impact A special, arming at 900 revolutions per minute, intended to determine if this size of fuse could be used to explode 12-inch mortar

shell on water impact. After 3 had been tested in 12-inch mortar (October 29, 1901), and the first 2 on water failed to explode, the plungers of the remainder were returned to the arsenal to be fitted with the locking device which holds the pin in the armed position after it is once rotated to that position.

Lot 2. Twenty-five centrifugal A, arming at 1,500 revolutions per minute. Of these 11 were fitted with the pin-locking device, marked R. P. L., and 14 were without that device, marked R. P. In the tests in 7-inch mortar (November 20–26, 1901), 5-inch siege gun (November 27, 1901), and 5-inch R. F. gun (December 5, 1901), the R. P. and R. P. L. fuses were fired alternately with and without the holdback spring to determine the utility of the spring.

Lot 3. Twenty-five centrifugal C, arming at 3,000 revolutions per minute and without holdback spring. The primer shields were 0".004 thick. Of these 14 were fitted with the pin-locking device, marked R. P. L., and 11 were without that device, marked R. P. In the test in 3.2-inch field gun (December 6, 1901) 10 of the fuses were provided with the delay-action cap, which will be described later.

Lot 4. Twenty centrifugal, side impact W, arming at 900 revolutions per minute. Of these 10 were fitted with the pin-locking device, marked R. P. L., and 10 were without that device, marked R. P. In the tests in 3".2 field gun (December 18, 1901), and 12-inch mortar (December 23–24, 1901), primer shields 0.004 of an inch thick were substituted for those used previously (0".0015 thick) to diminish the liability to irregular delay action.

The following conclusions are drawn from the trials:

1. The design affords a remarkable degree of safety for handling and transportation, even with the lowest arming resistance (or number of revolutions per minute) required in service, as shown by the shop tests at Frankford Arsenal. In 79 fuses tested by firing under varied conditions at the proving ground no prematures have occurred, and with the different arrangements of parts provided for experiment, such as the removal of holdback spring, the introduction of the pin-locking device, etc., each pattern of fuse has shown generally satisfactory performance in the projectiles for which it is intended.

2. The exceptional failures will be noted as follows: In the 8 C fuses fired from 3.6-inch mortar, December 10 and 11, 1901, two shell at 10° elevation glanced from the ground without exploding, while three others fired under the same conditions exploded. The fall of the three remaining projectiles in this series was lost to observers and the explosion indeterminate. The exceptionally low angle of projection employed, coupled with the low velocity of this piece, is thought to account for the two failures observed.

One C fuse out of 17 fired through wood screens failed to explode.

The failures of the centrifugal A fuse in 7-inch mortar shell were overcome by using R. P. L. fuses without holdback springs (see rounds 5 and 9, records of November 20 and 26, 1901). With the centrifugal side impact A fuse, four out of five 7-inch mortar shell exploded on land and the fifth was recovered with the primer shield indented (see record of December 18, 1901). The irregularity in fall of 7-inch mortar shell at the shorter ranges can not but induce some failures in any fuse.

Some failures of the centrifugal side impact W fuse are noted in the 12-inch mortar firing records of December 6, 12, and 23, 1901. It is believed the record is largely in error in these cases and that explosions occurred so far beneath the surface of the water as to be unseen by the observers at the firing point. On December 24 three observers (officers) were stationed at the 3,000-yard target, and the shell were fired to strike water within about 400 yards of the observers. The first was a sand-loaded shell, and then two fused shell were fired, both of which exploded well under water. The explosion gave only a slight sound, but was clearly indicated by the continued disturbance of the water from below. The observers at the firing point saw no evidence of explosion and would have reported both of the fused shell as failures.

Three explosions of shell in 7-inch howitzer will be noted in the firings of December 9, 1901. These were undoubtedly due to the breaking up of the shell in the bore and not to the fuse. Cast-iron shell of 125 pounds weight for the 7-inch mortar were at that time being used in the 7-inch howitzer. The pressures reached about 27,000 pounds, and the shell proved too weak to withstand it.

3. The holdback spring should be omitted. It tends to cause failure of the fuse to explode when the projectile strikes with a side or glancing blow and is not required to prevent premature action in flight. It moreover detracts from the safety of the fuse in handling, since the firing pin will strike the blank face of the fuse cap and can not revolve to the armed position except when the plunger is in contact, or

nearly so, with the rear of its seat, and, in the absence of the spring to hold the plunger in that position, arming and ignition of the fuse under any circumstances of dropping or rolling, etc., in handling seems almost impossible.

4. The fuses for 7 and 12 inch mortar projectiles should be of the side-impact pattern, to meet possible conditions of fall of the projectiles at the shorter ranges. It appears, however, that for all ranges at which the 12-inch mortar will probably be employed—that is, from about 2,600 yards upward—the projectile will fall tangent to the trajectory and strike by direct impact. These two patterns should also be provided with the pin-locking device because of the relatively low velocity of rotation of the projectiles, which may, with the reduced charges, not afford such margin over the arming resistance of the fuse as to insure rigidity of the firing pin in its armed position during flight and on impact of the projectile.

The fuses for field and siege guns (including 3.6-inch mortar) and for direct impact generally, having a high velocity of rotation, do not require either the side-impact or locking features.

5. The revolving-pin percussion plunger can be applied in altering the service percussion fuses on hand, replacing the plunger only and using the same fuse bodies, caps, and primers. This will be particularly applicable for the preparation of any A, W, and M (or low C) fuses required for immediate issue, including the replacement of the A fuses recently recalled from service. The retention of the present fuse cap is permissible in this case, since it is fairly efficient as proved by experiment and in service use; its delay action is variable, however, and merits improvement for future manufacture.

6. The revolving-pin percussion fuse of future manufacture should be provided with a delay-action fuse head or cap, having a primer orifice 0.1 inch in diameter, a primer shield 0.004-inch thick, and giving 0.02 second delay. This, however, does not involve the principle of the fuse, which resides essentially in the plunger and will be considered apart.

DELAY-ACTION PERCUSSION FUSE CAP.

Fuse heads of this description were furnished from Frankford Arsenal in response to the board's request of September 14, 1901.

The device (drawing not furnished herewith) consists of a separate fuse head conforming generally in exterior dimensions to the ordinary head. The interior parts comprise a central, hollow metal stem containing compressed mealed powder, directly in front of the percussion primer and surrounded by a small magazine of rifle powder. The stem is pierced laterally with a hole communicating with the magazine to give a length of mealed powder train suited to the time of burning desired. The magazine communicates with the bursting charge of the shell by the interposition only of a crimped brass disk in the usual manner.

Several lots of these fuse caps, differing only in length of train as cut at the arsenal, were tested, and the firing records are inclosed herewith, as follows:

Lot 1. October 30, 1901, 8 rounds with service C fuse, 3.2-inch gun No. 113, 4 caps, marked No. 1, length of train 0.1 inch, and 4 marked No. 2, length of train 0.3 inch.

Lot 2. December 6, 1901, 10 rounds with revolving pin C fuse, 3.2-inch gun No. 113, length of train 0.022 inch.

Lot 3. December 18, 1901, 4 rounds with service C fuse, 3.2-inch gun No. 35, length of train 0.022 inch, slightly reduced.

Lot 4. December 23, 1901, 12 rounds with service C fuse, 3.2-inch gun No. 113, 6 caps, marked No. 1, length of train 0.012 inch, and 6 marked No. 2, length of train 0.022 inch.

The projectiles were fired with full charges, giving a muzzle velocity about 1,685 feet per second, through pine-board screens to ignite the fuse. The screens used with lot 1 were in part 4 inches and in part 12 inches thick; the remaining screens were uniformly 6 inches thick.

The distances of the points of burst in feet beyond the screen were observed as follows:

Length of train.

Number of round.	0.3-inch, lot 1.	0.1-inch, lot 1.	.022-inch.			0.012-inch lot 4.
			Lot 2.	Lot 3.	Lot 4.	
1	573	195	55	35	....	30
2	501	210	57	55	75	15
3	510	216	45	50	72	35
4	180?	165	45	47	135?	44
5	....	....	....	....	83	45
6	....	....	66	....	205?	41
7	....	....	46	....	....	....
8	....	....	50	....	....	....
9	....	....	50	....	....	....
10	....	....	50	....	....	....
Probable mean value	528	204	51.5	46.7	76.7	35

Taking the velocity of the projectile to be 1,650 feet per second after penetrating the screen, and considering only lot 2 for 0.022 length of train, these distances reduced to time become:

Length of train.	Elapsed time of delay.	Delay action per 0.01 inch of train.
Inches.	*Seconds.*	*Seconds.*
0.3	0.32	0.0106
.1	.123	.0123
[a] .022	.031	.0141
.012	.023	.0191

[a] Lot 2.

The results show a very consistent outcome of results for the device in the vicinity of the delay action desired—that is, 0.02 of a second—except for the irregular action of the 0.022 train in lot 4, wherein it was undertaken to duplicate the results previously obtained with the same nominal length of train in lot 2. It is known that lot 4 was prepared at the arsenal at a different time from lot 2, and it would appear that some variation was made in shop work. The results indicate that a train length of 0.01 inch will give the delay action required; but, because of the irregularity noted, the board deems further tests necessary, which should be made either with this device or a modification of it as suggested by Captain Dunn that can be made at Frankford Arsenal.

SHOP TESTS OF CENTRIFUGAL PERCUSSION FUSES.

The following shop tests are prescribed:

(1) Arming resistance:

An allowance of ±250 revolutions per minute will be permitted for all centrifugal acting plungers required to arm at 2,000 revolutions per minute or higher; 10 per cent to be tested.

For the 7M and 12M fuses arming at 1,200 revolutions per minute, the allowance will be —100 revolutions per minute; 100 per cent to be tested.

(2) Jumbling test:

In a wooden box 16 by 11 by 5 inches, inside diameter, revolving 30 times per minute about one of its diagonals for four hours, a loose fuse must not show any marks on primer shield; 1 per cent to be tested.

(3) Jolting test:

A hinged cast-iron lever 16 inches long contains in its end an adjustable wooden fuse holder, and by a motion of a cam this end is raised 4 inches 35 times per minute and allowed to drop on an iron anvil. A fuse is thus dropped for one hour on its point, base, and side, respectively, and the primer shield must not be marked; 1 per cent to be tested.

(4) Inclined plane rolling test:

A fuse plunger assembled in a spool-shaped holder is rolled down an inclined plane formed by fixing at an angle of 45 degrees a wooden strip 2 inches wide, upper edge planed smooth. At the bottom the spool is suddenly arrested by a wooden anvil placed perpendicular to inclined plane for side impact fuses, and so arranged for non-side impact fuses as to arrest first the base end of spool and revolve it 90 degrees to cause the point to strike the anvil. The spool, with 1½ inch outside diameter of stem, must roll from a perpendicular height of 12 feet without marking the primer shield.

(5) Primer test:

With plunger armed and locked, the primer must explode when fuse is dropped point down on a steel anvil, the height of fall in inches being the ratio of 2,000 to the weight of the plunger in grains.

(6) Dropping test:

A fuse dropped 30 feet, point down, on a cast-iron anvil 1 foot square by 6 inches thick, resting on a solid foundation, must not explode or mark the primer shield.

RECOMMENDATIONS.

The board submits the following conclusions and recommendations:

1. Base percussion fuses required for immediate issue, excepting the service high C (and 15 seconds combination) fuses, will be prepared by substituting the revolving-pin plunger for the ring-resistance plunger now in use. (Frankford Arsenal should now be directed to make these alterations.)

2. Percussion fuses to be hereafter manufactured, including also the plungers used in detonating fuses for high-explosive shell, will be of the revolving-pin type with 0.02 second delay action, and primer shield 0.004 inch thick, and without hold-back spring.

3. The new model percussion fuses, whether base or point insertion, will have the following designation and characteristics:

Fuse designation.	Arming revolutions per minute.	Diameter of thread.	Service use.
		Inches.	
F—model 1902	2,000	0.875	3-inch, 3.2-inch, and 3.6-inch field guns, and 3.6-inch mortar shell charged with black powder. Detonating fuses made with the Peirce siege fuse stock.
S—model 1902	2,000	1.125	5-inch siege gun and field howitzer, 5-inch and 6-inch R. F. guns, and 7-inch howitzer shell charged with black powder.
7M—model 1902	2,000	1.125	7-inch mortar shell charged with black powder.
12M—model 1902	1,200	1.5	12-inch mortar shell charged with black powder. Detonating fuses made with Peirce torpedo fuse stock.
12M (special)—model 1902	1,200	1.125	Detonating fuse made with Peirce D. P. fuse stock.

Fuses F and S have centrifugal action only, while fuses 7M, 12M, and 12M special have, in addition, the side impact and pin-locking features.

4. The use of these percussion fuses, except where employed for the ignition of detonating fuses, will be limited generally to cast-iron shell for target or other peace practice. Steel shell charged with high explosives and detonating fuse will be employed in war.

5. No base percussion fuse is recommended for issue with the 12-inch

mortar cast-iron shell on hand which are tapped for the A fuse. These shell may be issued in target practice with blank fuse plugs and sand loaded, as ordinarily, and if powder-charged shell are required for target practice, those fitted for the 12M (former W) fuse will be supplied.

6. It is most desirable that all cast-iron shell, of whatever kind or caliber, hereafter made with the intent to use a bursting charge should be fitted for a point instead of a base percussion fuse, to avoid danger of premature ignition by entrance of powder gases around the fuse plug.

But the board is of the opinion that it is advisable to make only solid cast-iron projectiles for target practice with all classes and calibers of cannon, as is now done for 8, 10, and 12 inch B. L. rifles, and to supplement such issues with a limited number of high-explosive steel shell for practice with exploding shell, as well as to accustom the use of the high explosive shell in service.

This is not intended to displace the allowance of shrapnel for target practice, but that of cast-iron shell only. If the latter is not a war weapon, little advantage can be gained by its use in time of peace, and for drill and practice only the cast-iron solid projectile should serve as well as the shell.

7. In the manufacture of all fuses for the service it should be exacted, as a rule, to send 25 of each pattern of the first lots made to the proving ground for proof test, and thereafter 1 per cent of each from future lots of the same patterns.

R. Birnie,
Major, Ordnance Department, U. S. Army, President.
E. B. Babbitt,
Captain, Ordnance Department, U. S. Army.
B. W. Dunn,
Captain, Ordnance Department, U. S. Army.

The Chief of Ordnance, U. S. Army,
Washington, D. C.

Inclosure 1. Five plates.
Inclosure 2. Firing records, in 5 parts.

(35650—Enc. 21.)

FRANKFORD ARSENAL BASE PERCUSSION FUZE W.

EXPERIMENTAL. (Captain Dunn's design.)

0 1 2

SCALE OF INCHES.

FIG. 1.

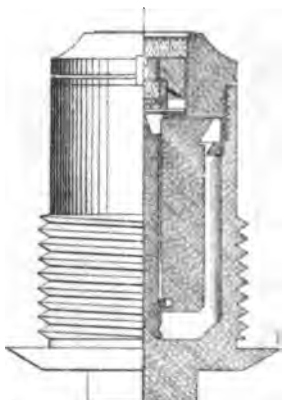


FIG. 2.

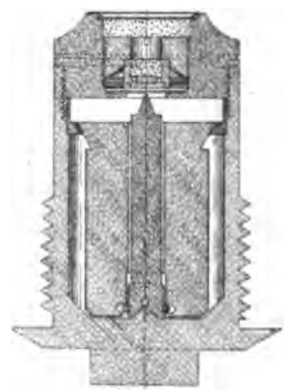
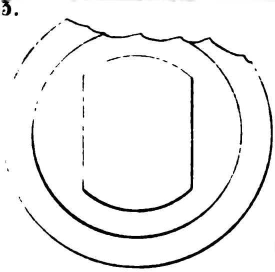


FIG. 3.



FRANKFORD ARSENAL
October 17th 1899.

Appendix VI. 1902

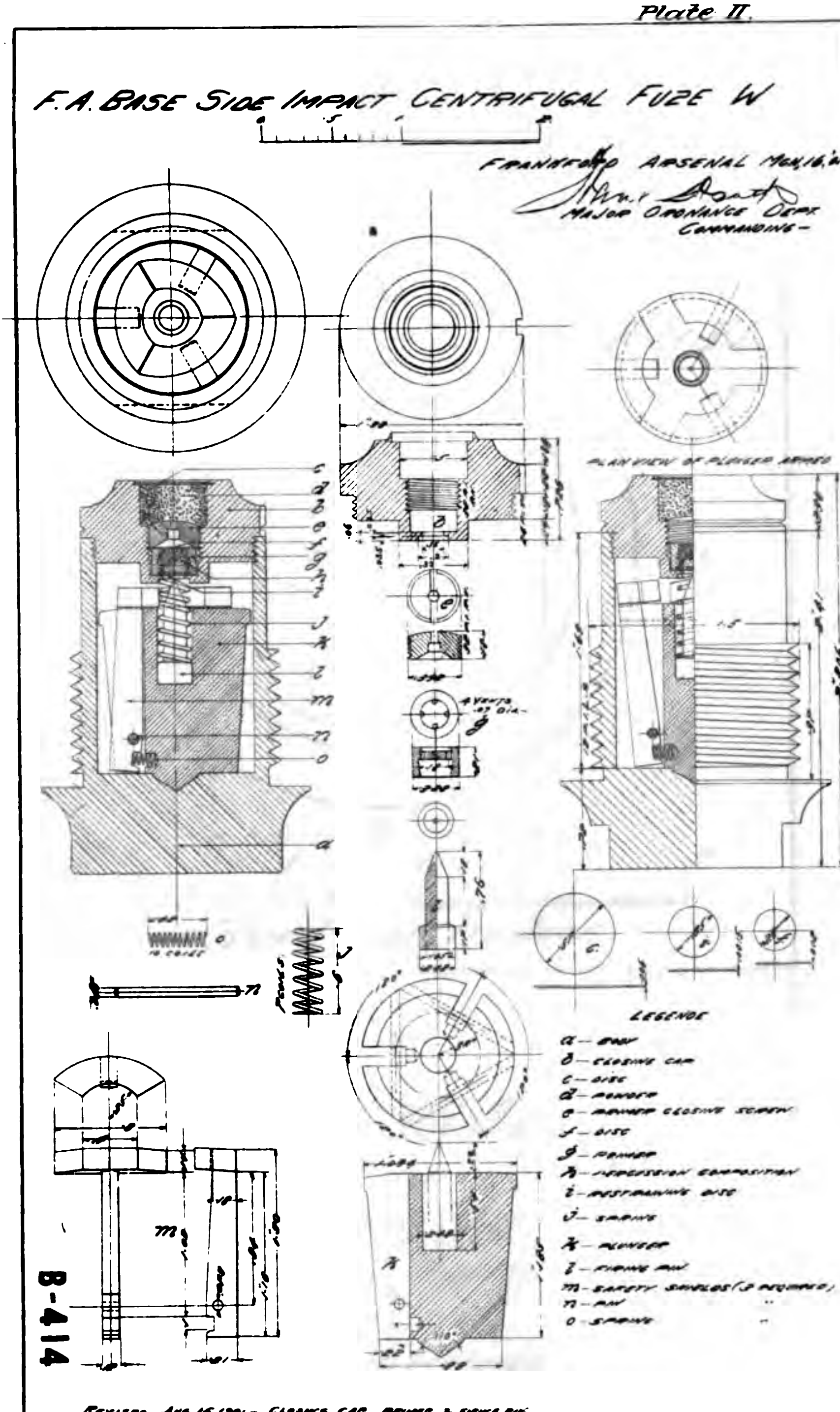

F. A. BASE SIDE IMPACT CENTRIFUGAL FUZE W
FRANKFORD ARSENAL
MAJOR ORDNANCE DEPT.
COMMANDING -
PLAN VIEW OF PLUNGER ARMED
LEGEND
a — BODY
b — CLOSING CAP
c — DISC
d — POWDER
e — POWDER CLOSING SCREW
f — DISC
g — PRIMER
h — PERCUSSION COMPOSITION
i — RESTRAINING DISC
j — SPRING
k — PLUNGER
l — FIRING PIN
m — SAFETY SHIELDS (2 REQUIRED)
n — PIN
o — SPRING
B-414
REVISED. AUG. 15 1901 - CLOSING CAP, PRIMER & FIRING PIN.
Appendix VI, 1902.

Plate III.

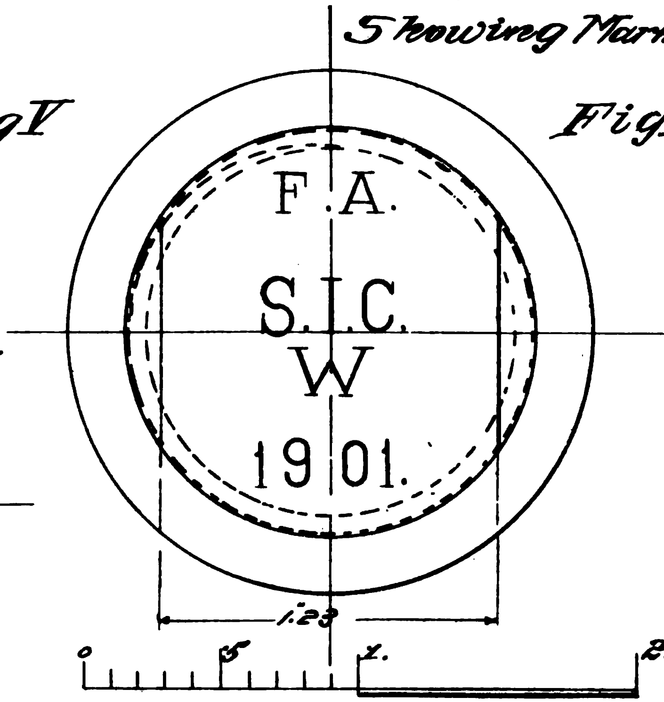
-iral groove has 3 turns per inch.

Plan View of Base

Showing Marking

gV

Fig VI.



Scale of Inches.

DE IMPACT CENTRIFUGAL FUSE "W"

-ankford Arsenal. Aug. 23rd. 1901.

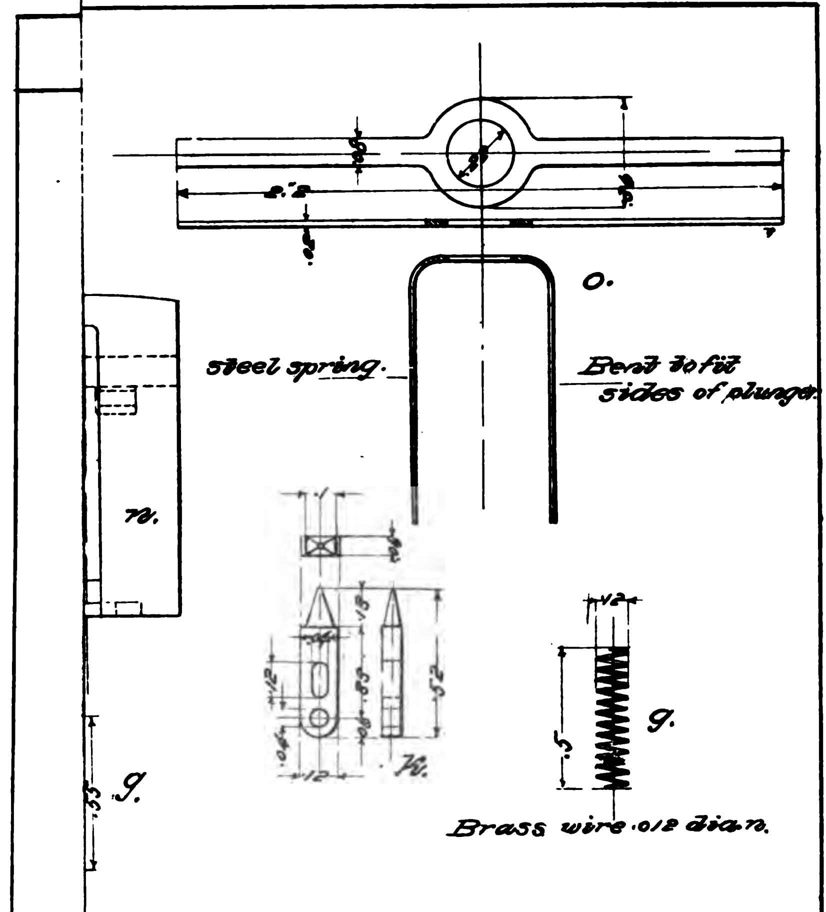
-amined: J.A.B.-	Approved:
-jor Ordnance Dept. Commanding.	Brigadier General. Chief of Ordnance.

-ivision	Drawing	File.

Ord 57 2

B 413

Plate IV.



OLVING PIN CENTRIFUGAL FUZE-A.

a
b
c ...kford Arsenal U.S.A. Nov. 6. 1901.

...amined. J.W.B. | Approved:-

...M. Heath

...or Ordnance Dept. Commanding. | Brigadier General. Chief of Ordnance.

...ision.	Drawing.	File.

Ord 57 2

B 4

Appendix VII.

METHODS OF INVESTIGATION AND TEST OF HIGH EXPLOSIVES FOR THE BURSTING CHARGES OF PROJECTILES.

In the investigation of high explosives the Board has adopted the following programme:

I. Information from the Inventor.

1. Color and form of material. If granular or molded, give dimensions.
2. Chemical composition. (Confidential if desired.)
3. Facility of manufacture. (Confidential if desired.)
4. Relative strength or force as compared with black rifle powder or explosive gelatine. If estimated, explain method; if determined by experiment, state how.
5. Commercial purposes for which the material is or may be used.
6. Results of tests, if any, that have been made to show:

(a) Safety in handling.
(b) Sensitiveness to friction and shock.
(c) Means required to produce good detonation.
(d) Keeping qualities under exposure to moisture, heat, cold, and continued storage.
(e) Actual firing tests from guns.

7. Proposed method of loading in shell.

Note.—Concise answers under the separate headings are desired.

II. Laboratory Examinations.

1. Stability, or time required to start decomposition at the temperature of 150° F.
2. Effect on material of temperature higher than 150° F., especially temperature of ignition or explosion, as the case may be, together with the character of the explosion.
3. Note hygroscopic qualities.
4. Sensitiveness to shock as compared with other high explosives, determined by a measured blow on an anvil.
5. Relative susceptibility to detonation, determined by bursting of lead tubes, using fulminate of mercury detonators.
6. Specific gravity and gravimetric density.
7. Determine "residue from flash" and "mineral ash" as approximate measures of production of "smoke."
8. Chemical action on metals, if any.
9. Chemical composition and calculated force.
10. General remarks.

The laboratory examination is most important and by the use of the impact testing apparatus established at Frankford Arsenal enables a fair opinion to be formed in advance of the quality of the explosive and its capacity to withstand the firing tests. The value of these laboratory results has been confirmed by the firing tests. In this apparatus a small measured quantity of the explosive is placed in a cavity (about 0.2 of an inch in diameter) of a steel block serving as an anvil. A piston is superimposed and arranged to be struck by a 5-pound weight falling from varying heights. The "drop in inches" measures the relative degree of sensitiveness. The quantity of explosive tested measures one grain or less, depending upon its density.

The relative strength of an explosive (supplementary to the laboratory tests) and its susceptibility to detonation is determined by exploding various calibers of shell charged with the explosive, by means of the detonating fuses, and observing the character of the fragmentation.

III. General Requirements.

A satisfactory high explosive for shell should fulfill the following requirements:

SAFETY AND INSENSITIVENESS.

1. Should be reasonably safe in manufacture and free from very injurious effects upon the operatives.

2. To warrant further test must show a relatively safe degree of insensitiveness in the impact-testing apparatus used by the Department.

3. Must withstand the maximum shock of discharge under repeated firings in the shells for which it is intended.

4. Must stand the shock of impact without explosion when fired in unfused shell against the strongest target that the shell alone will penetrate without breaking up. The first test of this kind to which a new explosive is subjected is to fire it in a 6-pounder shell against steel plates of varying thickness to determine the limit of endurance of the explosive. The limit of the strength of a 6-pounder shell in penetration is represented approximately by a 3-inch face-hardened steel plate.

DETONATION AND STRENGTH.

5. Must be uniformly and completely detonated with the service detonating fuse.

6. Should possess the greatest strength compatible with other necessary requirements.

STABILITY.

7. Must not decompose when hermetically sealed and subjected to a temperature of 150° F. for one week.

8. Should be preferably nonhygroscopic, and must not have its facility for detonation affected by moistures that can be absorbed under ordinary atmospheric exposure necessary in handling.

9. Must not attack ordinary metals used in projectiles and fuses to an extent that can not be prevented by simple means.

10. Must not deteriorate or undergo chemical change in storage.

GENERAL CONDITIONS.

Loading.—This must not be attended with unusual danger and should not require exceptional skill or tedious methods. It is very desirable that the explosive be capable of compact loading either by melting or compressing into solid blocks.

Supply.—Should be possible to procure the explosive quickly and in quantity in this country at a reasonable cost.

The Ordnance Board, U. S. A.,
March 7, 1902.

(23100—Enc. 424.)

APPENDIX VIII.

TEST OF NIGHT SIGHTS FOR SEACOAST GUNS.

ORDNANCE OFFICE,
Washington, D. C., June 30, 1902.

Prior to January, 1900, the Ordnance Department had not made any experiments with the view to the adoption of a night sight for the larger caliber seacoast guns. This was partially due to the fact that the night sights provided prior to that time for the 5-inch and 6-inch rapid-fire guns were not satisfactory, and because there had been no great demand for such sights for the larger caliber guns.

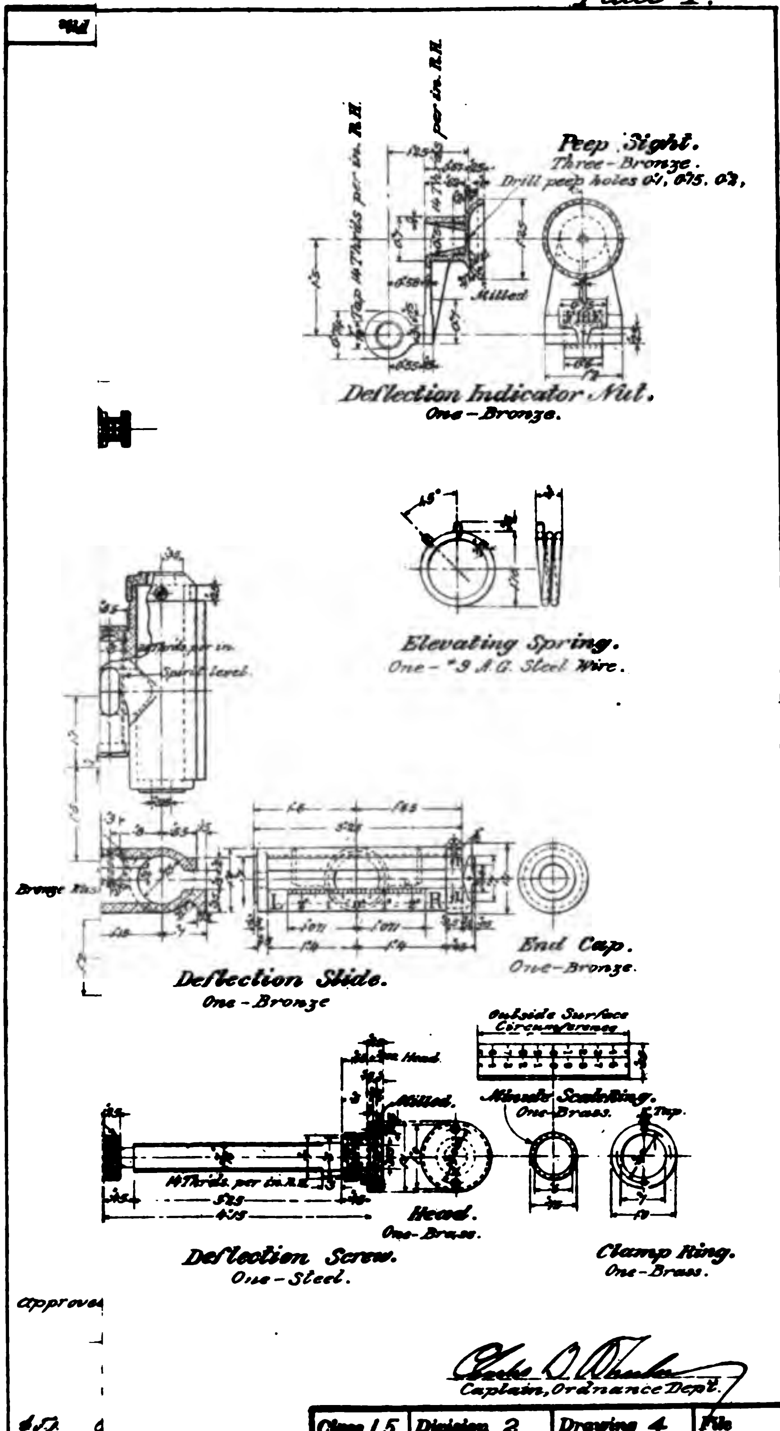
With a view to improving the night sights on the rapid-fire guns, and in an endeavor to determine whether or not night sights were necessary or desirable for guns of all calibers, the Department designed a night sight in which the rear sight was a peep sight and the front sight a small point of light. This sight is shown on the drawings attached hereto. (Pl. I.)

One of these sights was manufactured by the Warner & Swasey Company and sent to the Sandy Hook Proving Ground for trial by the Ordnance Board. The Board—

> tried the sight on one of the guns by manipulating it and sighting on harbor lights. On a moderately dark night no other object could be secured for aiming. The gun could be brought to bear upon the light by means of the sight with tolerable facility. The peephole in the rear is considered superior to the rear electric light for night sight. Three sizes of peephole furnished are 0″.1, 0″.15, and 0″.2. The larger size (0″.2) is deemed the best, as it gives the most light to the eye without perceptible parallax. The polished surface of the outside of the sight bar in the instrument under trial is objectionable, as it gives a reflected image of the front light at the peephole. It is suggested that this surface be given a dull finish, like that now on the eyepiece, to prevent reflection.
>
> Additional electric lights of the same pattern as used for the electric sights were tried for reading elevation and deflection scales and found to be practicable. The circle of light thrown by one of these is rather small and may require some enlargement of the axial orifice through which light is emitted.

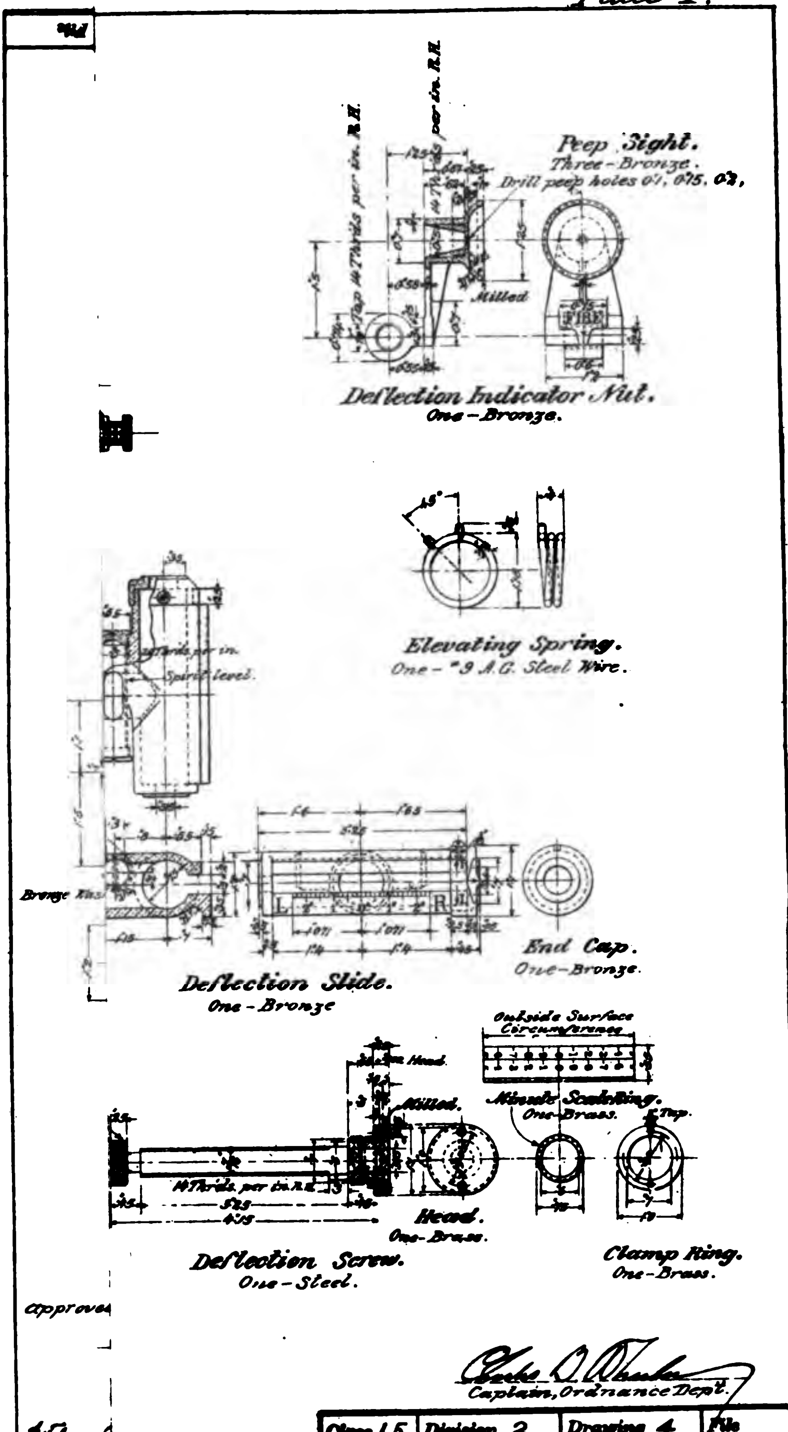
The tests of the Ordnance Board were not conclusive as to the effectiveness of the night sights over the ordinary sights with or without illuminated cross wires, and in order to enable a thoroughly practical test to be made, eight additional sights, with the improvements suggested in the test of the first sight embodied, were ordered from the Warner & Swasey Company and one issued to each of the fortifications in the maneuver district for trial by the artillery troops. It is hoped that the reports of the commanding officers of these posts will indicate conclusively what action should be taken by the Department in reference to such sights.

Plate I.



Ord 57 2

Plate I.



Ord 57 2

quadrant of the field. The field embraces a view of the top and front end of the bar for a distance of about 20 inches. It is thought this obstruction of the field will be immaterial if the glare be obliterated. The sight bar has now a smooth-finished, blued surface. It must either be made so dull as to obviate any reflection from the metal or it may be covered with light-weight dark canvas.

2. In the matter of adjustment. As now arranged the adjustment of the line of sight parallel to the axis of the gun may be made either by laborious fitting of the sight brackets or by marking the index lines for zero of the scales as a final adjustment. The latter method would, however, prevent the sight from being changed from one mounting to another. It is suggested that the front end of the bar may be made with adjustable fittings and clamps to allow enough motion both vertically and horizontally to provide for any adjustments required with brackets that have been assembled with ordinary care.

3. Provided the pistol box be retained (and unless the arrangements suggested in paragraph 5 be adopted) it must be removed to a position that will not interfere with the sight. A new place can be arranged on the inside of the shoulder rest, somewhat to the left and rear of the present position.

4. For convenience in sighting it is desirable to move the eyepiece (telescope and peep sight) about 2 inches farther to the rear. This should be done by simply lengthening the bar at the rear. With this change there will be no interference of the sight with the carriage in elevating. The cross head (deflection slide) of the sight shank, however, so nearly touches the inside metal of the elevating bracket that it would be advisable to provide clearance by removing 0''.25 from the face of the bracket.

5. Some additional convenience in sighting might result from removing the bar sight bodily 1 inch to the left; to do this and to avoid all interference with the carriage it will be necessary to provide a stop so that the lower end of the sight shank will bring up against it before the interference commences, and to arrange a friction clutch in the elevating gear of the sight so that the stop will push the arc up and not allow interference to come into action. It is questioned, however, whether this will not introduce complications including instability of the sight in position which will more than counterbalance the probable advantage.

6. It will be noted that the pistol box will not be used if the magneto-electric firing box is substituted for the present electric firing arrangements, as now contemplated.

The location of the night sight and magneto box for 5-inch carriage is shown on drawing dated July 10, 1901, which was forwarded to your office by the commanding officer of the proving ground on the 13th instant. The electric front sight is controlled by a rheostat placed on the side of shoulder rest. A double wire cable, with ends in the battery box, connects the rheostat and the front sight. The control of the reading lights is placed at the electric battery box. This is considered a reasonably good arrangement and the best that can be made in view of the difficulty of placing the battery box within reach of the gunner at the sight.

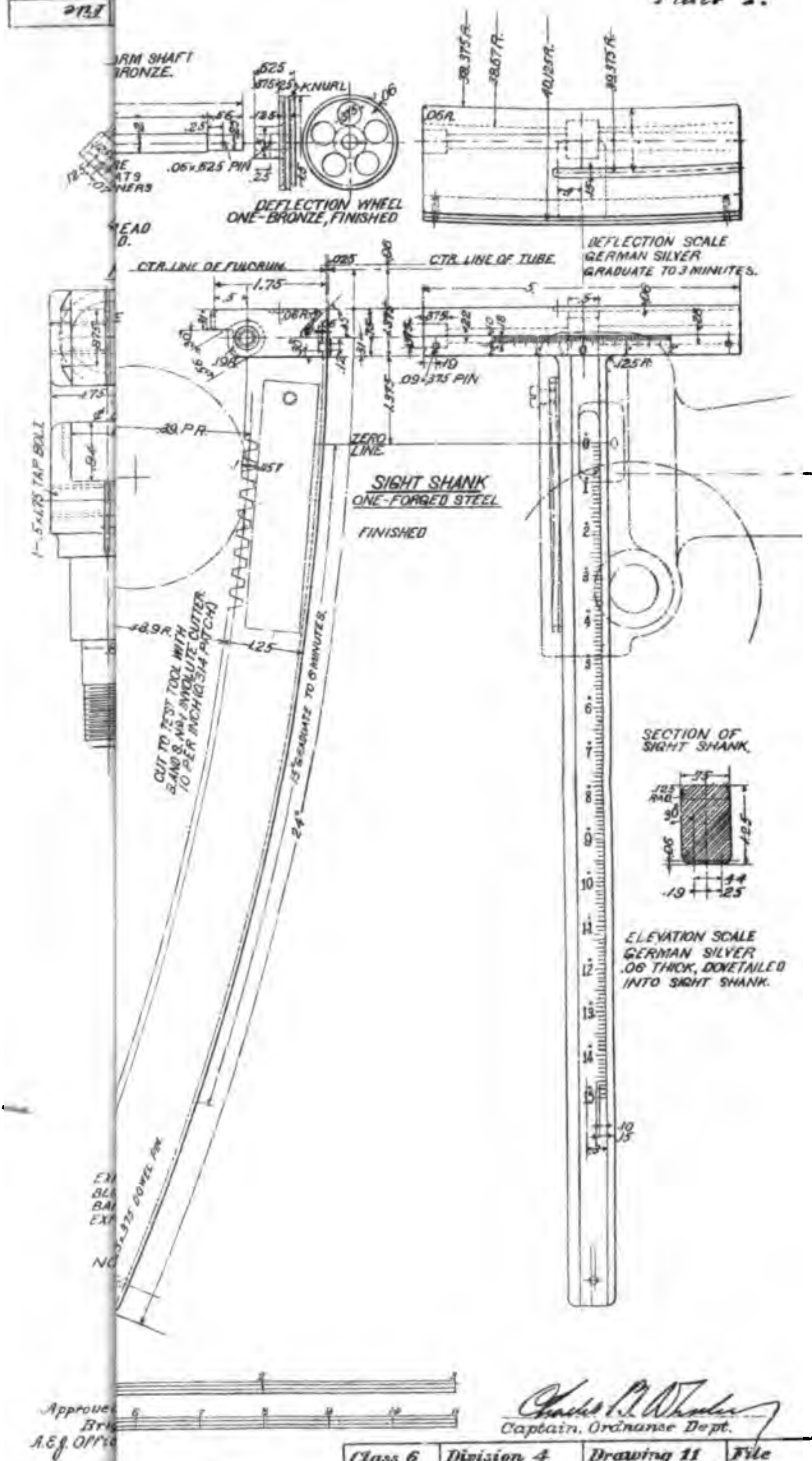
Attention is invited to the board's report of July 3, 1901, on the pattern night sight for details relating to the reading lights.

R. BIRNIE,
Major, Ordnance Department, U. S. A., President.

E. B. BABBITT,
Captain, Ordnance Department, U. S. A.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

Plate I.



Captain, Ordnance Dept.

Class 6	Division 4	Drawing 11	File

For the

APPENDIX X.

TEST OF TELESCOPIC SIGHT WITH VERTICAL AND HORIZONTAL HAIRS.

Capt. E. M. Weaver, Artillery Corps, U. S. Army, in an indorsement on a report to the Chief of Ordnance of artillery practice of student officers at the artillery school at Fort Monroe, Va., dated June 16, 1901, in referring to the use of the telescopic sight in that practice, stated:

> * * * It would be advantageous to have the vertical cross hairs of the telescope divided into points. * * * A gunner, then observing the splash, could read the error in range in points, knowing the range (as he does from the P. F.) and the slope of fall (from the table), he could at once tell the error in yards. Indeed, it seems to me the possibilities of a good telescope (with the cross hairs divided into points) as a range-finder are worthy of being exploited. When a ship comes into view, before she enters effective range it would be possible for the gunner to determine the linear measurement of some prominent part, say, the mast. This once ascertained, the angle it subtends on the vertical wire, in points and fractions thereof, would give the range by multiplying the value of one point by 1,000. The gunner could thus determine the range continuously as long as that target was held. * * *

This suggestion was referred to the commanding officer of Frankford Arsenal, and, after consultation with Messrs. Warner & Swasey, of Cleveland, Ohio, it was found impracticable to divide the vertical cross wire itself into points. A glass reticule was therefore placed as nearly as possible in the focal plane of the object glass of the latest model of telescopic sight. On this glass reticule a vertical line, graduated as suggested by Captain Weaver, was engraved. The interior horn scale was omitted, and graduations for deflection were also engraved on this reticule. By this arrangement the platinum cross wires were retained, the interior horn scale being replaced by the reticule, as described.

In regard to this sight, the commanding officer of Frankford Arsenal stated:

> With this graduated vertical line, Captain Weaver suggests that two purposes can be accomplished: First, in target practice, by keeping the intersection of the cross wires on the target and observing the splash, the angular distance between the splash and target can be measured on the scale, from which the error in range can be deduced; second, when a ship passes a point whose range is known, the angle subtended by a prominent object, as, for instance, from the top of the mast to the water line, can be measured and this height quite closely determined; after which, by the variations in the angle subtended by this object the variations in the range of the moving vessel can be determined, and the ability to do this with the ordinary sight of the gun might be very useful in case other and more delicate methods with the position finder should fail.
>
> In the first of the above purposes suggested, the telescopic sight would practically have to perform the functions of a depression range finder. The height of the

instrument above the water would have to be known and taken into consideration, and for any ordinary height the variations in the angle in passing from the target to the splash are such that it could not be measured on the vertical graduated line with any degree of accuracy. In determining errors in range, therefore, this method has no practical value. For the second of these purposes, however, this arrangement appears to be admirably adapted, and as it can be introduced with little trouble or expense, and without in any way impairing the efficiency of the instrument for other purposes, its use is recommended.

As numerous complaints have been made of the lack of power of these sights, a second eyepiece has been provided having a power of about 8 or double the standard. These eyepieces can be readily interchanged as desired. A test of these eyepieces will demonstrate the wisdom of the department in reducing the power of the model 1898 M sight, for it will be seen that the eyepiece of high power is of little use except in very clear, bright weather, and that under ordinary conditions the low power is much more efficient.

As high power is demanded and properly so for seacoast purposes, the only remedy is to provide a telescope with a larger objective—from 2½ to 3 inches in diameter. * * * This involves the giving up of this instrument as a portable sight. Its use on the gun trunnion should be discarded; the mounting should be a permanent part of the carriage, connected, if possible, with the elevating device and in such a way as to be unaffected by the shock of recoil, so that the telescope can remain in its mounting during firing. The telescope is the only part that need be detachable from the carriage. It should be habitually kept secured in a wooden box in the same manner as the azimuth instruments. * * *

This sight thus modified was referred to the Ordnance Board for test, the result of which is reported by the Ordnance Board, as follows:

As stated in the report of the commanding officer of Frankford Arsenal, December 5, 1901, returned herewith, this sight was fitted with the glass reticule to replace the horn scale in the standard sight, pursuant to the suggestions of Captain Weaver, Artillery Corps, that the vertical cross wire be divided into points. This was not considered practicable, and Messrs. Warner & Swasey provided the glass reticule which has a vertical as well as a horizontal scale, graduated to 3-minute divisions and extending 2 degrees on each side of the center for each scale. Besides the standard eyepiece having a power of 4, the sight is also provided with one having a power of 8.

By means of the vertical scale it is proposed to keep track of the range of a ship by observing the angle subtended by some prominent object on it—as for instance, from the top of a mast to the water line when passing a point at a known distance—and then by the variations of this angle determining the range at other points.

The following tests were made to determine the accuracy with which the range could be measured. A vertical mast was placed upon a platform car and moved along the range. The masts used were respectively 10 and 25 feet high. Results are given in the following table:

[Vertical object sighted at 10 feet high.]

Reading of vertical scale.	Height of object by reading at known range.	Range computed from height of object determined at known range.	Known range.	Measured ranges.
Minutes.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
6.5	11.35	....	6,000	6,000
9	....	4,840	....	4,500
11	....	3,540	....	3,751
14	....	2,780	....	2,700
[Vertical object sighted at 25 feet high.]				
30	26.15	....	3,000	3,000
26	....	3,460	....	3,600
21	....	4,280	....	4,500
18	....	5,000	....	5,100
17	....	5,300	....	5,400
15	....	6,000	....	6,000
14	....	6,430	....	6,450
13.5	....	6,650	....	6,750

The first reading at each of the above heights was the known range as indicated. There was difficulty in reading the angles nearer than the thickness of the horizontal wire, of 1½ minutes. It is seen that the error is fairly constant and relative ranges may be determined quite accurately.

The guns at the proving ground are so near the water level that no actual tests could be made of the value of the vertical scale for determining the error in range by having the intersection of the cross wires on the target and reading the angle to the splash, which was the second object of the use of the scale suggested by Captain Weaver.

The board concurs with the commanding officer of Frankford Arsenal that the use of the vertical scale for this purpose has little practical value. If the gun were mounted at a considerable height above the water, some value might be derived at short ranges, but not for the usual height of gun site. If, for example, the gun be 50 feet above the water level and firing at a range of 3,000 yards, an error of about 150 yards in range would subtend an angle of 1 minute only. The telescopic sight is not adapted to such measurements.

In the sight tested, the main divisions of the vertical scale on each side of zero are marked 10 and 20, evidently an error, as these divisions should be 1° and 2°. Tests made in different kinds of weather indicate that the amount of light is not sufficient for the power 8 eyepiece except in very clear weather. The power 4 eyepiece is generally more efficient.

The Board finds that the glass reticule, graduated with vertical and horizontal scale as in the sample sight tested, does not interfere with the use of the instrument as a telescopic sight, and that the addition of the vertical scale may be useful in keeping track of the range of a ship. The horizontal scale simply replaces the horn scale. The Board therefore recommends the use of the glass reticule.

The report of the Ordnance Board and the modified sight were forwarded to Captain Weaver for his information and for such experimentation as he might desire to make, and the following is his statement in regard to it:

The glass reticule used in this sight is a great improvement on the graduated wire originally suggested. It is also an improvement on the horn scale used for the deflective scale of our telescopic sights.

The degree of accuracy developed in the experiments exceeds that anticipated, especially with the small telescope of the model 1898 sight.

It will be borne in mind that the original suggestion contemplated the use of the vertical "point" scale for the purpose of range finding, with a much longer telescope, one having a 3-inch objective and a power of 12 to 20, such as is to be provided for the new sights now understood to be in process of manufacture.

Such an increase of power without sacrifice of light should give even better results, it is thought.

In any event, the method offers to each gunner a means of determining his range individually and independently of the regular range-finding system, should that be put out of action by shot or accident; and, inasmuch as it in no way interferes with all other functions of the sight, it would seem advisable to introduce the feature in the telescopes of all the new sights. Such a scale would in fact be useful in all military telescopes.

It would add to the accuracy and ease of reading if there could be a movable horizontal wire in addition to the fixed one; the latter (fixed) could perhaps be simply a line worked on the reticule. Mr. Swasey, in conversation, has said that such a movable horizontal wire could readily be introduced.

It is desirable, of course, that the unit of the scale should be a true "point"—that is, the tangent of the angle 3.43 feet—and that the marks on the scale and the horizontal wire be as fine as possible.

APPENDIX XI.

TEST OF ZEISS STEREOSCOPIC BINOCULAR RANGE FINDER.

THE ORDNANCE BOARD, U. S. ARMY,
NEW YORK ARSENAL,
New York City, February 11, 1902.

SIR: The board respectfully submits the following report of trial of the Zeiss stereoscopic binocular range finder, pursuant to your instructions of April 2, 1901 (O. O. letter No. 35935—Enc. 16).

The range finder tested is the smallest of three similar instruments manufactured by Carl Zeiss, Jena, Germany. The instrument has a base, or distance between object glasses, of about 20 inches (51 cm.), with a magnifying power of 8, and is graduated for ranges between 90 and 3,000 meters. The weight, with leather case, made to be carried over the shoulder, is 10½ pounds. The weight of the tripod support is 9¾ pounds, and that of the alternate staff support 4½ pounds. This instrument is intended for use of infantry or for reconnoissance on the field.

The stereoscopic binocular range finder is based upon vision with both eyes, thereby utilizing the power of stereoscopic vision. This advantage is further augmented by employing the so-called telestereoscope of Helmholtz, by means of which the limited field of stereoscopic vision of the naked eye can be extended at will in proportion to the base selected and the magnifying power of the lenses employed. The range finder is a double telescope in the image planes of which are fixed the distance scales. On looking with both eyes the marks of the scale appear balanced in space in perspective and enable the observer to read, at a glance, the distance of the object as seen through the glasses by noting the place on the scale in which the object ranged on comes into it. If the object falls between marks, the fraction of the interval is to be estimated. The two telescopes are rigidly connected parallel to each other, but the distance between the eyepieces is adjusted to suit the width between the eyes of different observers. The telescopes, each of which forms one-half of the mounting and in which the rays of light on entering the object glasses are twice deflected at right angles to reach the eyepieces, are surrounded by a metal sheathing with an outside covering of leather to avoid errors due to unequal temperature.

The object glasses are fitted for the attachment of reflectors, by means of which, using an auxiliary light, the telescopes are illuminated and observations for range can be made at night to determine the range of a light in the distance.

The exactness of measurement obtainable with the instrument for a determined distance depends, first, on the power of vision in the human eye, which for stereoscopic definition is limited in the average person to about 30 seconds; and second, on two optical constants in the double telescope. These constants are the base or distance between the object glasses and the magnifying power of the instrument. With these factors, and taking 65 millimeters as the average distance between the eyes, the following values have been deduced, which represent the fundamental instrumental errors in the three models of this range finder or the limits of accuracy which may be anticipated under favorable conditions:

	Model— I.	II.	III.
Magnifying power	8	14	23
Base.....centimeters	51	87	144

Distance (meters).	Error in Model I.		Error in Model II.		Error in Model III.	
	Meters.	*Per cent.*	*Meters.*	*Per cent.*	*Meters.*	*Per cent.*
500	9	1.8	3	0.6		
1,000	35	3.5	12	1.2	5	0.5
2,000	141	7	50	2.5	18	.9
4,000			200	5	70	1.8
8,000					280	3.5

These values are based upon perfect adjustment of the instrument and a supposed clear and tranquil atmosphere. It is stated that the errors will increase more rapidly with the distance than the table indicates in proportion to the amount of murkiness or disturbance in the air. On the other hand, it is claimed that the limit of stereoscopical definition of the eyes may, by practice with excellent eyesight, be reduced from an angle of 30 to one of 10 seconds, which would divide the errors in the table by three.

The instrument also provides a means for measuring the length of an object at a distance perpendicular to the range. The scale for this, seen on looking through the glasses, is a horizontal line divided into 20 parts. Each division measures 1 meter per 1,000 meters of range, and the length of the object in meters will be given by—

$$L=\frac{\text{Range}}{1,000}\times \text{number of divisions of scale covering the object.}$$

The same scale can be used for reading the height of the object by holding the instrument in a vertical position.

Full instructions for the use of the instrument, its adjustment, etc., are contained in the accompanying pamphlet in French (35935—Enc. 24). Reference should also be made to the lecture of Dr. C. Pulfrich (35935—Enc. 21) and to a discussion of the principles of the instrument by Capt. Henry C. Davis, U. S. Artillery Corps (35935—Enc. 12).

A small instrument for measuring the interocular distance by means of which each person may determine this measurement for himself, to be used in setting the distance between the eyeglasses of the range finder, is also provided.

The instrument affords advantage of giving instantaneous results, and requires but a single observation. It can, however, be successfully used only by persons of good sight and whose eyes are approximately equal in strength.

TESTS.

The data pertaining to the series of trials made at the proving ground are herewith, marked Appendix A.

The first series illustrates what accuracy may be expected from persons having but little experience in using the instrument. Three officers observed the same objects. Over land the average reading at known distances gave errors of range varying from 1½ per cent at 183 meters to about 10 per cent at 925 meters. At the same time the difference of the three observers between themselves amounted to from 2½ to 8 per cent on the 8 ranges included, except in one case where the three were alike. Attempted readings at 1,840 meters (2,012 yards) or greater distances gave most irregular results. Over water the clear view afforded better definition of the object than could be obtained over land, particularly upon the mast of a passing vessel, read 1,300 meters distant.

In the second series the observer, Lieutenant Tschappat, first found considerable errors which were about proportional to the square of the range as they should be if the instrument were out of adjustment a constant amount for all measurements. After adjustment to read correctly at 400 meters this observer obtained a series of 11 readings between 100 and 700 meters with errors generally insignificant for practical purposes at these short ranges, the maximum being about 3 per cent.

The third series was taken by an intelligent enlisted man somewhat versed in the use of surveying instruments, after sufficient practice to familiarize himself with the range finder. It was again found necessary to adjust the instrument for this observer, notwithstanding which the errors of range amounted to from 5 to 8 per cent at ranges between 430 and 610 meters.

The range finder was next used by Mr. Paul Beer, civil engineer employed at the proving ground, aged 28 years, whose eyesight could be well adapted to the instrument. As with previous observers, it was found necessary to specially adjust the instrument. The following table combines the results of this observer on land ranges after adjusting the instrument. The object observed was a flag held aloft except for the first thirteen readings, on October 1, when a man standing on the ground was observed.

Column B includes the readings of September 27, 28, and 30, excepting the second and third, on September 30, which are in doubt. The conditions of atmosphere were exceptionally good on September 28 and 30. Column C contains the readings on October 1, marked "a. m." and "p. m." The conditions of atmosphere were very good in the morning and poor in the afternoon. The percentage of errors are recorded as observed, while the distances are given to the nearest even 100 meters for each observation. This does not materially alter the showing for accuracy of the instrument.

(Table I.)

Range (meters).	Errors of observation. B.	Errors of observation. C.	Range (meters).	Errors of observation. B.	Errors of observation. C.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
200	1.6	0.5 a. m.	1,200	0.6	8.2 p. m.
300	10.0	4.9 a. m.	1,300		8.2 p. m.
400	6.6	0.3 a. m.	1,400	1.5	7.6 p. m.
500	0.2 Sept. 27.	2.4 a. m.	1,600	2.2 Sept. 28 and 30.	
600		1.6 a. m.	1,800	2.8	
700	1.0	1.1 a. m.	1,900	1.0	
800	0.5	2.1 a. m.	2,600	10.7	
1,000	2.4, 28th	10.3 p. m.	2,800	8.8	
1,100		10.8 p. m.	2,700		8.4 p. m.
900		1.75 a.m.			

The results taken under favorable conditions of atmosphere are fairly good, as seen in Column B, up to 1,900 meters; in Column C, up to 900 meters. The p. m. observations, October 30, made under unfavorable conditions of atmosphere began at 1,000 meters in Column C and show very poor results. The observer remarks that for distance beyond 1,500 meters the readings are very uncertain and are influenced by the mind's idea of the distances, and the position of the image in the scale depends largely upon the imagination. When the atmosphere is disturbed by heat radiation good results, even at comparatively short distances are difficult to obtain. A fair degree of approximation may be obtained for all ranges up to 1,500 meters, provided the sky forms the background, and up to 800 meters whatever the background.

The readings at night were made by this observer and also by Captain Burr, the object observed being a lantern held aloft.

A summary of all the readings by Lieutenant Tschappat, Private Robinson, and Mr. Beer, made after an adjustment of the instrument for each one separately, under varying conditions of atmosphere and including the night observations by Captain Burr, gives the following average percentages of error:

(Table II.)

Range (meters.)	Number of observations.	Error.	Range (meters.)	Number of observations.	Error.
		Per cent.			*Per cent.*
100	2	2.6	1,300	1	8.2
200	4	2.2	1,400	3	3.5
300	6	3.9	1,500	1	5.2
400	5	2.5	1,600	2	2.6
500	6	3.7	1,800	3	4.1
600	4	2.2	1,900	2	5.2
700	4	1.45	2,000	1	9.3
800	4	1.0	2,300	1	3.7
900	6	2.0	2,400	1	5.1
1,000	2	6.35	2,500	2	10.0
1,100	1	10.8	2,700	3	10.6
1,200	4	3.65	2,800	1	8.8

The scale for measuring the length of object perpendicular to the range was tested by readings on 4 targets distant 914, 1,829, 2,286, and 2,743 meters. The actual width of each target is 39 feet. The widths estimated from the instrumental readings for range gave 36.3, 38.8, 37.5, and 42.7 feet. Using the known ranges in connection with the instrumental readings of the width scale, the deduced widths of the targets are 37.5, 38.4, 39, and 39.1 feet.

CONCLUSIONS.

The model of range finder tested is compact and strongly made and appears not liable to get out of adjustment. Its accuracy in the hands of a person whose eyesight is well adapted for using it and under favorable conditions of atmosphere is sufficient to make it useful in ranging for infantry fire. Under very favorable conditions a fair degree of accuracy for this purpose is obtained up to about 1,900 meters. Under unfavorable conditions of atmosphere little reliance can be placed upon the indications of the instrument beyond 1,000 meters at best. It is possible, too, that the general familiarity of the observers at the proving ground with the distances observed by them has led to a better record of results than would be obtained in general use in a new country and with unfamiliar objects. Perhaps the best adaptation that can be made of the instrument is its use for reconnoissance by an officer on the field. The excellent glasses and the ready means afforded for obtaining distances up to a certain limit make this the best instrument known to the board for the purpose, while its weight is such that it can be carried without difficulty.

The board recommends that the instrument now on hand be sent to the school at Fort Leavenworth, Kans., for trial there, with a view to determine its utility for general service.

The board recommends, also, that an instrument of the next larger size (Model No. II), having a base length of 87 cm., as stated, be purchased and issued to the Light Battery School at Fort Riley for trial in service. It is believed that this instrument will be of use with light batteries for giving trial ranges very quickly, and that it would be found more serviceable than the largest size of the instrument (Model No. III) for field use.

The Model No. III instrument might be tried for seacoast service, but its accuracy is not sufficient for seacoast range finding, and it is thought the seacoast service is now provided with better and more accurate means of observation than any that this instrument could supply.

R. BIRNIE,
Major, Ordnance Department, U. S. Army, President.
E. B. BABBITT,
Captain, Ordnance Department, U. S. Army.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

APPENDIX •A.

ZEISS BINOCULAR RANGE FINDER.

Observations made April 27–30, 1901, by officers with instrument as received and without adjustment.

Object.	Observers.			Average observed distance.	Actual distance.	Error.
	Major Birnie.	Captain Crozier.	Lieutenant Morton.			
	Meters.	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Meters.*
Range post:						
No. 2	175	185	180	180	183	− 3
No. 3	260	270	260	262	274	− 12
No. 4	330	350	340	340	366	− 16
No. 5	420	420	420	420	457	− 37
No. 6	510	515	500	508	549	− 41
No. 7	605	600	590	598	640	− 42
No. 8	700	715	660	692	732	− 40
Target:						
No. 1	850	820	810	827	925	− 98
No. 2	....	1,350	1,400	1,375	1,840	−465
No. 3	2,700	1,500	1,700	1,967	2,297	−330
No. 4	....	1,800	2,200	2,000	2,754	−754
Light-house	650	650	640	647	Difference by observers, 10.	
Range tower	325	345	325	332	20	....
Water tank	360	365	....	363	5	....
Office staff	410	410	410	410	0	....
Water:						
Spar buoy	1,100	1,100	1,100	1,100	0	....
Bell buoy	1,100	1,050	1,100	1,083	50	....
Red buoy	1,550	1,500	1,600	1,567	100	....
Vessel in channel between buoys	1,300	....	....	....	....	....

NOTE.—Major Birnie: View indistinct, from refraction, beyond 1,000 yards down the range. Clear view to sea, and "easy" to read passing vessel. Red buoy easy; two other buoys more difficult, though nearer.

Observations by Lieut. W. H. Tschappat, Ordnance Department, U. S. Army, to test the accuracy of the instrument. Stakes were planted at distances corresponding to points on the scale of the instrument, and these distances were then measured. The following table gives the reading of the instrument, the actual distance, and the error, in meters:.

Instrument.	Measurement.	Error.
Meters.	*Meters.*	*Meters.*
100	104.5	4.5
130	138.3	8.3
150	162	12
200	228	28
225	259	34
250	298	48
275	327	52
300	357	57
350	432	82
400	502	102
450	576	126
500	665	165
550	767	217

These errors are about proportional to the square of the actual distance, as they should be, if the instrument were out of adjustment, a constant amount for all the measurements. It was therefore thought possible to correct the errors by adjustment of the instrument.

This was done by turning the *left* adjusting screw until the 400-meter point fell on a stake planted at the distance from the instrument. After the adjustment the instrument gave the following results:

Instrument.	Measurement.	Error.
Meters.	*Meters.*	*Meters.*
100	97	− 3
150	146.8	− 3.2
200	200	0
250	252	+ 2
300	300	0
350	343	− 7
400	400	0
450	439	−11
500	485	−15
600	602	+ 2
700	695	− 5

These errors appear to have no particular relation to each other, and are such as might arise at any time in using the instrument. They are due to error in judgment or to indistinctness in stereoscopic effect.

After a distance was measured the direction of the error was in most cases apparent, showing that closer results could be obtained by practice.

August 15, 1901.—Readings made by Private Roberson, after sufficient practice to familiarize himself with the instrument:

Instrument.	Measurement.	Error.
Meters.	*Meters.*	*Meters.*
180	183	− 3
265	274	− 9
345	366	−21
425	457	−32
505	549	−44
585	640	−55
645	732	−87
710	823	−113
830	914	−84

Instrument was then adjusted so as to read correctly on an object distant 500 meters. Adjustment made by Private Roberson under proper supervision. Following readings were then taken:

Instrument.	Measurement.	Error.
Meters.	*Meters.*	*Meters.*
920	914	+ 6
815	823	− 8
710	732	−22
610	640	−30
505	549	−44
430	457	−27
355	366	−11
290	274	+16
195	183	+12

The above results were so irregular as to lead to the conclusion that Private Roberson could not properly use the range finder. He is an unusually intelligent soldier and somewhat versed in the use of surveying instruments.

Readings below made by Mr. Paul Beer, a civil engineer employed at the proving ground.

Except where otherwise stated, the object observed was a flag held aloft so as to be plainly visible above the surrounding objects.

September 27, 1901.

Series A. Before adjustment of instrument.]

Instrument.	Measurement.	Error.
Meters.	*Meters.*	*Meters.*
183	183	0
282	304	−22
425	457	−32
540	579	−39
590	640	−50
645	732	−87
780?	882	−102?
[Series B.	Instrument adjusted.]	
830	823	+ 7
740	732	+ 8
550	549	+ 1
370	396	−26
300?	333	−33?
180	183	− 3

Observation continued from 1.30 to 4.30 p. m.

The first set of readings were low, i. e., the distances read were less than the actual distances.

The reading questioned in series A is uncertain because of bad atmospheric conditions. Before taking the second set of readings a flag was held at 500 meters and the instrument adjusted to read this distance.

It is impossible to adjust the instrument accurately, but at 500 meters a close approximation to the true adjustment may be made by one familiar with the instrument.

Series B were taken with the adjusted instrument, and the observed distances are in fair accord with the actual.

September 28, 1901, a. m.

Instrument.	Measurement.	Error.
Meters.	*Meters.*	*Meters.*
825	823	+ 2
1,030	1,006	+24
1,190	1,188	+ 2
1,200	1,188	+12
1,350	1,371	−21
1,520	1,554	−34
1,900	1,920	−20

The sky was partly clouded and the atmospheric conditions were ideal for observing.

The object observed (a red flag) stuck just above a mass of shrubbery in the last three readings, and considerable speculation was introduced in determining the instrumental reading. The position of the image in the scale was very uncertain, and the speculation as to its position was no doubt influenced by the mind's idea of the distance.

The "mind influence" works strongly for all distances beyond 1,500 meters.

September 30, 1901, p. m.

Instrument.	Measurement.	Error.
Meters.	*Meters.*	*Meters.*
1,800	1,751	+ 49
2,200?	2,118	+ 82?
2,300?	2,300	0?
2,800	2,529	+271
3,000	2,757	+243

An ideal day for observing. Sky clouded and atmosphere still.

The second observation is questioned, as the flag was held at both 2,100 and 2,300 yards, one of which distances was missed by the observer.

The third reading is also questioned. This was first read 2,300, then 2,500 meters, and the image seemed to oscillate between these two distances. The former distance was recorded.

The approximation between 2,000 and 3,000 meters are very uncertain, and different observers would obtain widely different results.

The image does not really oscillate, but its position in the scale depends largely on the imagination of the observer. The apparent distance between the planes 2,000 and 3,000 is very small, and to interpolate between them is quite difficult.

The mind of the observer will naturally speculate as to the position of the image, and in whatever plane the mind imagines the image to be, it will apparently take that position.

If after a slight rest the observer takes another view and imagines the object to be in some other plane, the image will apparently take up its position in this new plane. This speculation is of course involuntary.

October 1, 1901.

A. M.

Instrument.	Measurement.	Error.
Meters.	*Meters.*	*Meters.*
182	183	− 1
263	274	− 11
365	366	− 1
470	457	+ 13
560	549	+ 11
650	640	+ 10
740	732	+ 8
840	823	+ 17
925	914	+ 11
935	914	+ 21

P. M.

1,110	1,006	+104
1,215	1,097	+118
1,285	1,188	+ 97
1,385	1,280	+105
1,475	1,371	+104
2,875	2,652	+223

For the first 13 observations the object observed was a soldier standing on the ground; for the last 3 the flag was used.

Atmospheric conditions during the morning were very good; during the afternoon very poor.

When the atmosphere is disturbed by heat radiation, good results, even at comparatively short distances, are difficult to obtain. This may explain the wide difference between the apparent and real distances in the p. m. readings. It is certainly very odd that these readings, with one exception, are about 100 yards too great.

A fair degree of precision may be obtained for all distances up to 1,500 meters, provided the object whose distance from the instrument is desired has for its background the sky. It may be relied on to give a fair degree of precision for all distances up to 800 meters, whatever may be the background.

Objects at sea, within the limit of the instrument, are more easily and quickly read than objects on land.

One can more easily and quickly read the distance of a man when still than of a flag which flutters.

The man with any dark background is more distinct, and his position with reference to the scale in the instrument more certain.

With a large dark object, such as a wooden target, for a background, the scale is distorted for all distances beyond 800 meters, and no credibility should attach to the readings greater than this under the above conditions.

It matters not at what distance the target may be, provided its image in the glass is greater than the apparent field occupied by the scale.

Heat radiation distorts the object observed, and this distortion increases with the distance of the object from the instrument.

Under poor atmospheric conditions, therefore, long-distance readings are not reliable, say, for distances beyond 1,000 meters.

It will require familiarity with the instrument (obtained through constant use) to so adjust it as to give precise readings for even the lesser distance.

A varying personal equation, which becomes more uncertain in value as the distance increases, and which may be either positive or negative, enters all readings.

Measurements of the length of front of objects at various distances from the observer.

Target.	Instrument.	Measurement.	Error in range.	Width scale.		
	Meters.	*Meters.*	*Meters.*	*Reading.*	*Meters.*	*Feet.*
No. 1	885	914	− 29	12.5	11.06	36.3
No. 2	1,850	1,829	+ 21	6.4	11.85	38.8
No. 3	2,200	2,286	− 86	5.2	11.44	37.5
No. 4	3,000	2,743	+257	4.35	13.05	42.7

Actual width of targets, 39 feet.

The width in meters is obtained from the formula:

W = width in meters.
S = scale reading.
E = horizontal distance in meters.

$$W = \frac{S\,E}{1{,}000}$$

The tabulated results are computed from the instrument readings for distance. Taking the known distance to the targets, their width as computed by the scale readings would be 37.5, 38.4, 39, and 39.1 feet.

Measurements of the height of objects can be made with the same degree of accuracy and by the same method as measurements of length of front.

Observations made at night, October 25, 1901, by Mr. Beer.

Instrument.	Measurement.	Error.
Meters.	*Meters.*	*Meters.*
3,000	2,652	+348
2,700	2,469	+231
2,500	2,378	+122
2,200	2,012	+188
2,100	1,920	+180
1,900	1,751	+149
1,600	1,554	+ 46
1,400	1,371	+ 19
1,250	1,188	+ 62

To light the scale a lantern was held in front of the instrument between the object glasses. A second lantern was exposed at different points on the range and readings of its distance taken. In the wind the light flickered, and it was consequently at times very difficult to determine its exact position with reference to the scale. Night was a bright moonlight one.

October 11, 1901.—Observations made by Captain Burr.

[Night exceedingly dark; atmosphere still.]

Instrument.	Measurement.	Error.
Meters.	*Meters.*	*Meters.*
625	640	−15
870	914	−44
1,540	1,463	+77

Readings at greater distances attempted, but operator was unable to get the stereoscopic effect. No difficulty was experienced in seeing the objective—a lantern held aloft. In fact, the lantern and scale were the only objects visible in the field of view, which should be the ideal conditions for accurate work by an experienced operator.

ARTILLERY SCHOOL,
Fort Monroe, Va., February 5, 1901.

SIR: I return the pamphlet and catalogue of the stereoscopical range finder, by Carl Zeiss, Jena, Germany.

The pamphlet contains the substance of a lecture on the instrument by Dr. Pulfrich, of Jena. It is a "popular" description, with principles stated very broadly and with almost no details of construction.

The following, it is thought, states the principles and indicates generally the probable details of construction of the instrument:

As stated in the pamphlet, the instrument is Helmholtz's telestereoscope adapted to range finding by the addition of scales placed in the image planes of the objectives.

The underlying principle is that of binocular vision, involving our ability to appreciate perspective. Each eye forms an image of the object viewed. These images fall on associated parts of the respective retinæ, nearly, but not mathematically, coalescing into one. The brain fuses these images and we see the object in perspective. According to Wheatstone, this fusion is an act of subconsciousness and by some means gives us the sense of space depth.

How this is accomplished is of no importance here, as we start from the well-known physical fact that if we view two points in space, binocularly, and if the optic axes of the eyes converge more in one case than in the other, we have a sense of space depth—that point for which the convergence is greater seeming nearer. Experience verifies this fact. As the object becomes more distant, the difference in convergence for a given distance becomes less, and finally, when the convergence is inappreciable, we fail to distinguish a difference in distance by this means alone. The stereoscopical range finder increases the distance at which the convergence becomes inappreciable by practically increasing the distance between the eyes.

The application of these principles to the range finder will now be considered. Let C and K be the similar objectives of two telescopes having their optic axes, C*n* and K*m*, parallel (see fig. 1). Let P and Q be two points taken for convenience on C*n* prolonged, P being only a little more distant than Q, but both at a considerable distance from C. Let L be a third point at stellar distance.

The images of L, by the objectives C and K, will be formed at *n* and *m*, respectively. The images of P and Q, by the objective C, will be formed practically together at *n*, while the images of these same points, by the objective K, will be formed practically at *p* and *q*. These images are real, and may be viewed by eyes at E*l* and at E*r*, and as the difference of convergence is negligible in the two cases, there would be no sense of a difference in distance. Now let the lines of sight converge till the right eye, E*r*, looks at *n*, and the left eye, E*l*, looks at *p* and *q*. Then, because of the above-mentioned peculiarity of binocular vision, *p* will appear at p_1 and *q* at q_1. We thus have an appreciation of space depth just as though we had looked at P and Q, *p* seeming farther than *q*. The truth of this is illustrated in figure 2. Let the intersections of the diagonal lines of the polygons represent *n* and *q*, while the upper left-hand corners of each figure represent *n* and *p*. Measurements show that the representatives of *n* and *p* are nearer together than the representatives of *n* and *q*, so that the conditions are similar.

Now, holding the paper at a convenient distance from the eyes, increase the convergence of the latter (cross them) till the right eye is looking at the left figure and the left eye at the right figure, when there will be seen three figures, the two originals and a third one between and standing out to the front of the other two, the intersection of the diagonals appearing in front of and nearer to the observer than the sides of the polygon. The middle figure will appear as a pyramid, with its apex to the front. It will require practice to accomplish this, but it is facilitated by holding a pencil tip between the figures and the eyes at such a point that the right eye projects it on the left point, and the left eye projects it on the right point. Converge the eyes on the pencil tip and the middle figure will appear. Now remove the pencil and look at the middle figure, ignoring the others.

Another peculiarity of binocular vision is encountered, for although the middle figure is clearly seen, the eyes are apparently not focused on any portion of that figure, which seems in front of the paper, but on the paper itself. This is shown by placing the pencil tip at the apex of the pyramid where it seems out of focus. This is the phenomenon of the stereoscope; in which case the instrument cuts out the original figures by a diaphragm, leaving only the middle one visible to both eyes. Hence the name of the range finder.

Figure 1 shows an inverting telescope which, by means of its erecting pieces, gives erect images. Suppose figure 3 to show the images of P and Q at n, and at p and q, and let the eyes be directed as shown in the figure; we will see p at p_1 and q at q_1, with a sense of difference in distance, p being on the right of q, just as P is to the right of Q as seen by the right eye. This is merely the effect of the erecting piece; each eye now views the image on its own side and the necessity for crossing them is obviated. Figure 4 shows the erecting prisms at zz. The prisms in this range finder not only reinvert the image but change the direction of the pencil of light at right angles twice, so that the lengths of the telescopes, $\frac{1}{2}$ (B—A), are perpendicular to the direction of sight (see fig. 5). P, C, K, n, m, are same as in figure 1. The image of P is at p_1, having been erected. Km is the focal distance of ocular K conjugate to the distance C P, and, since P is very distant, it is practically the principal focal distance $=f_1$. Oculars for viewing the images n and p are shown at S and T. The principal focal distance of T is T$m = f_2$.

The displacement of p from m (due to the fact that E = C P is less than infinity) $= a$, and φ is the corresponding vergency of the pencils entering the two telescopes. As seen through the ocular, p is in the direction of p_1, and θ is the angle of vergency of the rays entering the eyes (angle between Sn and Tp). θ is then the factor which determines whether P will appear nearer or more distant than another object, as Q, whose corresponding angle is θ^1. This is the telestereoscope.

Suppose now we place at n a vertical row of dots in the image plane of the objective C, the lowest one at n, and similarly at m place dots in the image plane of objective K, the line of dots inclining upward and to the left, with the lowest one at m. Counting from the bottom, let the consecutive dots in the two image planes be taken in pairs. Viewed through the ocular, each pair of conjugate points will combine, and a fused image of them will be seen. The fused images of another pair will be seen at a different distance from the eye; in other words, we see in the series of dots showing perspective a scale of distances in depth.

Assume that one of these dots in the image plane, mp, coincides with p or is projected on it. Then the fused image of this dot and its conjugate dot, and the fused images of n and p, will appear at the same space depth, and the image np of P is fixed on the perspective scale.

Suppose the positions of these dots in the image planes had been calculated to correspond to a certain scale of distances from the observer, as from 75 to 2,000 meters, and each was marked and designated in some way; then the observer directing his instrument on P would see the fused image np, at the same space depth as the fused image of two of the conjugate dots of the scale, and the distance to P would be immediately known. If the image fell between two points of the scale, the distance must be approximated by eye. With a scale so arranged, the telestereoscope becomes the stereooptical range finder.

The pamphlet does not give the details of the arrangement of this scale, or how it is mounted. The dots, of course, need not be in a vertical row in one image plane. They may be in any disposition, provided the conjugates are the proper distances apart. These distances, calculated as shown below, are laid off, and the scale of the drawing reduced by photography. It is not stated whether the scales are placed in a plane, or whether they lie on a focal surface corresponding to the focal distances conjugate to the different ranges. The scales are constructed from equation (1), below, in which a is the excess of the distance of np over nm for the inverting (fig. 1) and of nm over np for the erecting telescopes (fig. 4).

B and A in figure 4 are the same as in figure 5. E=CP and Km=f_1. From the similar triangles in figure 4 we have

$$\mathrm{E} : \mathrm{B} :: f_1 : a$$

$$\text{or } a=\frac{\mathrm{B}f_1}{\mathrm{E}} \ (1). \quad \text{Differentiating (1) we obtain } d\mathrm{E}=\frac{\mathrm{E}^2}{\mathrm{B}f_1}\, da.$$

For some other point near P, as Q, there will be formed an image near p and distant from it by da. From the triangle we have $a=f_1 \tan \phi$, and if ϕ is small, $da=f_1\, d\phi$. Similarly $da=f_2\, d\theta$ . . . (3). Putting the value of da from (3) in (2), we have $d\mathrm{E}=\frac{\mathrm{E}^2 f_2 d\theta}{\mathrm{B}f_1}$, and if V equals the magnifying power of the combination $=\frac{f_1}{f_2}$, we write $d\mathrm{E}=\frac{\mathrm{E}^2}{\mathrm{BV}}\, d\theta$ . . . . (4).

It is seen from figure 4 that θ is the angle of vergency of the two pencils entering the eyes from P, and hence determines the position of the fused image of n and p as regards space depth. Since the dots of the scale are in the same plane with n and p,

the same vergency will fuse a certain pair of conjugate dots, with the result that the fused image of p and n will appear at the same space depth as that of this pair of dots. If a second point, as Q, is considered at a distance dE from P, the vergency is changed by $d\theta$ and the fused image corresponding thereto will appear at the same space depth as the fused image of two other conjugate dots. Equation 4 shows that for a given value of dE there will be a greater change in space depth (as determined by $d\theta$) as V is greater.

Experiment (see pamphlet) indicates that if, for the average eyes, the difference in vergency, $d\theta$, is less than 30″, there will be no perception of space depth. Examining equation 4 we see that the least perceptible variation in E therefore corresponds to a value of $d\theta$ of 30″.

Suppose the average distance between eyes is 65 mm. = A, and let r be the distance to the point at which the parallax is $d\theta = 30''$. Then, since when θ is small we have $d\theta$ equal to $\frac{A}{r}$ . . . (5) we have $dE = \frac{E^2}{r\left(\frac{B}{A}\right)}V$ . . . (6)

From this equation, with the assumed value of A = 65 mm. and the value of r from $d\theta = \frac{A}{r}$ (7), we see that dE, or the change in range that will be perceptible, will decrease as B V increases and as E^2 decreases. Since the accuracy of the instrument increases as dE decreases, equation (6) shows the advantage of increasing B, the distance between the telescopes, and also of increasing the magnification V; it also shows that the accuracy of any instrument increases inversely as the square of the range.

In field glasses B = A, and the advantage is due solely to V, but in this range finder B = 51, 87, and 144 cm., respectively, for the three types, and, correspondingly, V = 8, 14, and 23. These three types have range scales as follows:

No. I, 75 to 3,000 meters; No. II, 300 to 5,000 meters; No. III, 700 to 10,000 m.

With this data, the following table is calculated, showing the errors in E, i. e., the values of dE for $d\theta = 30''$.

Range	Model No. I. V = 8, B = 51 cm. Error.	Model No. II. V = 14, B = 87 cm. Error.	Model No. III. V = 23, B = 144 cm. Error.
500 m	9 m., 1.8 per cent	3 m., 0.6 per cent	
1,000 m	35 m., 3.5 per cent	12 m., 1.2 per cent	5 m., 0.5 per cent.
2,000 m	141 m., 7 per cent	50 m., 2.5 per cent	18 m., 0.9 per cent.
4,000 m	564 m., 14.1 per cent	200 m., 5 per cent	70 m., 1.8 per cent.
8,000 m		800 m., 10 per cent	280 m., 3.5 per cent.

Model No. I is a hand instrument, and costs 750 marks. It may be used with a tripod or with a telescoping staff which costs 75 marks. Weight of instrument is 4.2 kg. and of the tripod 7.2 kg. The prices and weights of models No. II and No. III are not given. They are intended to be used with supporting tripods, or may be mounted permanently in fortifications. The instrument is patented in Germany and also in "some other countries."

This instrument possesses the advantage of giving instantaneous results, and requires a single observation. The accuracy of this range finder depends on keeping the telescopes parallel; this, the makers claim, is done by rigid attachments, and by the use of a covering of nonconducting material.

The scales must be very accurate and must not be displaced by use. The makers claim that the scales are capable of adjustment and that unless badly damaged they can easily be readjusted without sending back to factory. (No details given.)

It is claimed that the effect of the boiling of the atmosphere over heated fields, affects the rays entering the telescopes nearly alike, and the small difference causes the image to move back and forth slightly in space depth about its true place, which is estimated by taking a mean of extreme positions.

There is a method (no details) for verifying the parallelism of the telescopes at any time.

The field of view may be illuminated for getting the range of lights at night by reflecting light into the objectives from a piece of white paper placed over them and

at an angle of 45° with the line of sight, the object being seen through a slit in the paper.

This instrument can be successfully used only by persons of good eyesight and whose eyes are approximately equal in strength.

As in all other observing instruments, practice necessarily increases the observer's facility and accuracy. It is claimed that the minimum angle of convergence may, by practice with excellent eyesight, be reduced from $\theta = 30''$ to $\theta = 10''$. This would divide the errors in the table by three.

Examining the foregoing table, it is seen that, if as accurate as described, the portable model No. I might be of use with infantry. Model No. II would be quite advantageous with light artillery by giving instantly a trial range. Model No. III is 5 feet long and probably would not stand the rough travel with light artillery, but if it can, it is better and simpler than anything now in use in our service. Model No. III is within the required limits of accuracy at midrange (2,000 yards) for seacoast artillery, but its error is too great for greater distances to allow its use as a range finder for the guns. It might be useful in observing the point of fall of the projectile in rapid fire.

As the details of construction are not known, it is impossible to state whether a greater value than 144 cm. may be given to B without loss of accuracy, but if B may be increased to 288 cm., the errors would be within the recognized limits of accuracy for seacoast artillery. If the magnification may be increased without too much loss of light, the same result may be obtained in that way. These and several other questions of accuracy and durability can be determined only by experimenting with the instrument. This could be done at the Artillery School at Fort Monroe, Va.

A cut of model No. I stereoscopical range finder is shown in fig. 5.

Very respectfully,

HENRY C. DAVIS,
Captain, Seventh Artillery.

Plate I.

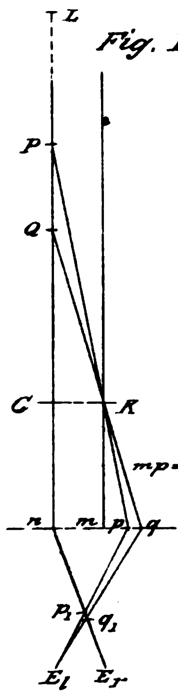


Fig. 1.

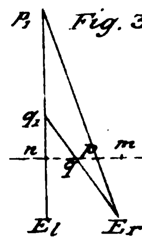


Fig. 3.

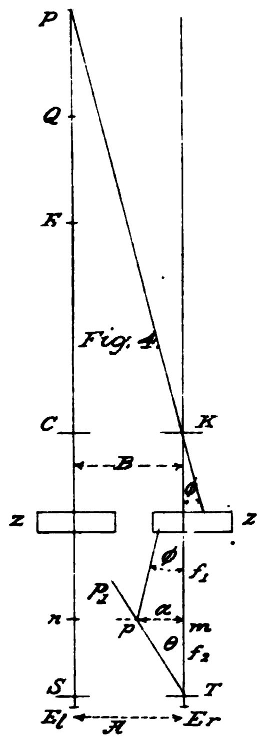


Fig. 4.

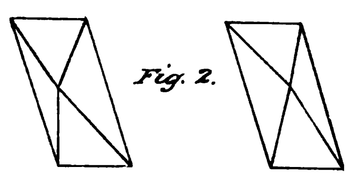
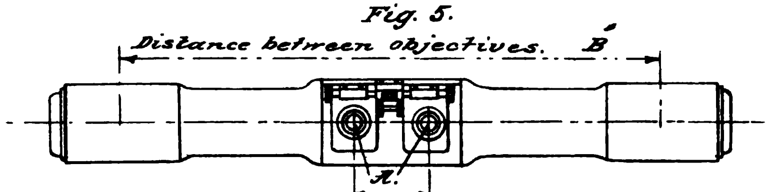


Fig. 2.

Fig. 5.



APPENDIX XII.

TEST OF COLE ELLIPTICAL BORE RIFLE.

WASHINGTON, D. C., *July 16, 1901.*

DEAR SIR: I have invented a gun with elliptical bore of .30 caliber, suitable to take the ordinary fixed ammunition of this caliber. I desire to have a thorough Government test, such as will demonstrate the quality of the gun for service. I desire to have the test made at the earliest convenience in order that I may be present.

Very respectfully,

W. F. COLE, M. D.

Gen. A. R. BUFFINGTON,
Chief of Ordnance, U. S. Army.

[First indorsement.]

OFFICE OF CHIEF OF ORDNANCE,
Washington, July 16, 1901.

Respectfully referred to the commanding officer, Springfield Armory, with instructions to test without delay the gun presented by Dr. Cole, who is authorized by this office to be present at such times during the test as he may desire.

A. R. BUFFINGTON,
Brigader-General, Chief of Ordnance.

[Second indorsement.]

SPRINGFIELD ARMORY, MASS., *July 18, 1901.*

Respectfully referred to the board of officers appointed by Post Orders, No. 43, of 1899, for immediate test.

FRANK H. PHIPPS,
Lieutenant-Colonel, Ordnance Department, U. S. Army, Commanding.

[Third indorsement.]

SPRINGFIELD ARMORY, MASS., *December 14, 1901.*

Respectfully returned to the commanding officer, Springfield Armory, with report herewith.

For the board.

JNO. E. GREER,
Ordnance Department, U. S. Army, President.

[Fourth indorsement.]

SPRINGFILLD ARMORY, MASS., *December 14, 1901.*

Respectfully returned to the Chief of Ordnance, U. S. Army; attention invited to the third indorsement hereon.

FRANK H. PHIPPS,
Lieutenant-Colonel, Ordnance Department, U. S. Army, Commanding.

REPORT ON DR. COLE RIFLE.

[Second indorsement on O. O. letter No. 36819.]

SPRINGFIELD ARMORY, MASS., *July 18, 1901.*

Respectfully referred to the board of officers appointed by Post Orders, No. 43, of 1899, for immediate test.

FRANK H. PHIPPS,
Lieutenant-Colonel, Ordnance Department, U. S. Army, Commanding.

SPRINGFIELD ARMORY, MASS., *December 14, 1901.*

The board, pursuant to the foregoing orders and indorsements, met at 1.30 p. m. July 18, 1901.

Present: Maj. John E. Greer, Ordnance Department, and Capt. Odus C. Horney, Ordnance Department.

Absent: Capt. Frank Baker, Ordnance Department, on leave per Ordnance Orders, No. 8, dated July 31, 1901, and Capt. John T. Thompson, sick in quarters.

Dr. W. F. Cole appeared before the board and presented for examination and test a caliber .30 rifle of his invention, having what he describes as an elliptical bore.

The length of the barrel of this rifle is the same as that of the service arm, 30 inches. The cross section of the bore is in the form of an ellipse, the short diameter being ".30, the long diameter ".31, and having a twist of one turn in 7".29.

Dr. Cole claimed for his gun greater accuracy and greater penetration than the ordinary rifle, the same ammunition being used in each.

In order to compare the accuracy of this rifle with the service rifle, firing was first conducted at 1,000 yards range with the following results:

Rifle.	Deviation.			Firer.
	Vert.	Hor.	Abs.	
Service (No. 326616)	31.34	11.67	33.4	R. T. Hare.
Do	24.40	11.88	27.1	Recorder.
Do	19.60	7.52	21.0	R. T. Hare.
Mean	25.11	10.36	27.2	
Cole	9.94	10.2	14.3	Do.
Do	8.90	12.0	14.9	Recorder.
Do	22.32	8.8	24.0	R. T. Hare.
Mean	13.72	10.3	17.7	

The penetration at this range was as follows:

Service—Mean of 5 rounds, 11.2 inches.
Cole—Mean of 5 rounds, 11 inches.

On the following day the test for accuracy was continued at 300 yards. As the results obtained with the service rifle at 1,000 yards on the preceding day were very unsatisfactory, a different rifle was used at this range. The results were as follows:

Rifle.	Deviation.			Firer.
	Vert.	Hor.	Abs.	
Service (No. 323821)	2.02	1.23	2.36	R. T. Hare.
Do	2.67	1.01	2.85	Do.
Mean	2.35	1.12	2.60	
Cole	2.94	2.23	3.69	Do.
Do	6.05	2.48	6.54	Do.
Do	6.69	3.45	7.53	Dr. Cole.
Mean	5.56	2.72	5.99	

It may be that the superiority shown by the 2-grooved or Cole rifling is due to the escape of gas in the 4-grooved barrel past the bullet, owing to too small diameter of the latter.

It seems safe to say that the 2-grooved or Cole system is preferable to the service system, and the board therefore recommends that a number—500 or more—barrels be so rifled and be assembled with the first Springfield magazine rifles manufactured. Suitable tests by marksmen in the service and at the armory can be then advantageously made.

There being no further business before it, the board then adjourned to meet at the call of its president.

JOHN E. GREER,
Major, Ordnance Department, U. S. Army, President.
J. PITMAN,
Major, Ordnance Department, U. S. Army.
JNO. T. THOMPSON,
Captain, Ordnance Department, U. S. Army, Recorder.

SPRINGFIELD ARMORY, MASS., *June 26, 1902.*

Proceedings and recommendation approved. The system of elliptical rifling is not new, but was presented over forty years ago.

FRANK H. PHIPPS,
Lieutenant-Colonel, Ordnance Department,
U. S. Army, Commanding.

(36819—1 Enc. 2.)

PROCEEDINGS OF A BOARD OF OFFICERS CONVENED BY THE FOLLOWING ORDER AND INDORSEMENTS:

POST ORDERS, No. 6. SPRINGFIELD ARMORY, MASS., *February 1, 1902.*

* * * * * * *

V. A board of officers is hereby appointed to meet at this armory from time to time to consider and report upon such inventions and devices as the commanding officer may submit to it. Detail for the board: Maj. John E. Greer, Ordnance Department; Maj. John Pitman, Ordnance Department; Capt. John T. Thompson, Ordnance Department.

FRANK H. PHIPPS,
Lieut. Colonel, Ord. Dept., U. S. A., Commanding.

(36819—Enc. 1.)

[Fifth indorsement.]

OFFICE OF THE CHIEF OF ORDNANCE,
Washington, July 14, 1902.

Respectfully referred to the commanding officer, Frankford Arsenal, inviting attention to the supplementary report of the board on the elliptical-bore rifle at Springfield Armory, dated June 14, 1902. It is stated that the superiority shown by this system may be due to the escape of gas in the 4-groove barrel past the bullet. In view of the improvements made in the caliber .30 rifle bullet by expansion of base to the diameter of 0.308 by swaging or cupping of metal by a conical punch (see 30024–B–236, Encs. 1–3), it is desired to ascertain whether the superiority of the elliptical bore will hold good using the improved bullet.

He is therefore instructed to furnish the commanding officer, Springfield Armory, with sufficient of the improved ammunition to make the comparative trials desired. That officer is instructed to repeat the firings with the two systems, using the improved ammunition, and report results to this office.

36819, 36819–Enc. 2, 36819–Enc. 3, 36819–Enc. 5, 36819–1–Enc. 2, and 36819–11 of this Ordnance Office file are herewith. Duplicate copy of supplementary report has been retained in this office.

WILLIAM CROZIER,
Brigadier-General, Chief of Ordnance.

On October 1 firings were conducted at 1,200 and 1,500 yards, with the following results:

At 1,200 yards.

Rifle.	Deviation.			Firer.
	Vert.	Hor.	Abs.	
Service (No. 323821)	36.5	25	44.2	R. T. Hare.
Do	21.6	11.1	24.3	Do.
Do	27.8	14	31.1	Do.
Mean	28.6	16.7	33.2	
Cole	23.5	15.9	28.4	Do.
Do	29.3	24.7	38.3	Do.
Do	17.8	19	26	Do.
Mean	23.5	19.9	30.9	
New model Springfield rifle, 2,300 feet per second velocity	24.6	25.1	35.1	Do.
	24.7	15.4	29.1	Do.
	21	15.5	26.1	Do.
Mean	23.1	18.7	30.1	

At 1,500 yards.

Rifle.	Deviation.			Firer.
	Vert.	Hor.	Abs.	
Service (No. 323821)	41.5	44.5	60.8	R. T. Hare.
Do	39.1	19.8	43.8	Do.
Mean	40.3	32.1	52.3	
Cole	28.2	33.6	43.8	Do.
Do	47.6	30.3	56.4	Do.
Mean	37.9	31.9	50.1	
New model	26.3	16.5	31.5	Do.
Springfield rifle, 2,300 feet per second velocity	27.6	35.3	44.3	Do.
Mean	26.9	25.9	37.9	

Before any further firings had been made, Dr. Cole made request that his rifle be returned to him, and this was done.

It will be seen by an examination of the preceding records of firings that the Cole rifle was less accurate than the service rifle at 300 yards, and, in general, slightly more accurate at longer ranges. The greater accuracy at long ranges would seem to indicate greater steadiness of the bullet in flight, but just how much of this increased steadiness is due to the system of rifling and how much to the sharper twists used in the Cole gun can not be determined by the limited number of firings thus far conducted; and a barrel for use in the service rifle has been rifled on the Cole system and a further series of firings is contemplated.

It is thought that the subject is worth thorough investigation, and positive conclusions can be drawn only after a large number of records have been made and examined. When the board shall have completed such a number of experiments as to enable it to form definite conclusions, further report upon the subject will be made.

John E. Greer,
Major, Ordnance Department, U. S. Army, President.
Jno. T. Thompson,
Captain, Ordnance Department, U. S. Army.
Odus C. Horney,
Captain, Ordnance Department, U. S. Army, Recorder.

Captain Baker, not having witnessed any part of this test, does not sign the report.

Approved, and respectfully forwarded for the information of the Chief of Ordnance, U. S. Army. Orders have been given for an exhaustive series of firings with a barrel rifled after Dr. Cole's plan, to ascertain if it possesses merit over our present system. If so, riflings of different lengths of twist will be tried to see which is best suited to the new rifle. The Cole system, if successful, will relieve, it is thought, any apprehension of jacket strippings of the bullet, and may admit of the use of a lead bullet giving a higher sectional density.

FRANK H. PHIPPS,
Lieutenant-Colonel, Ordnance Department,
U. S. Army, Commanding.

SPRINGFIELD ARMORY, MASS.,
December 14, 1901.

(36819—Enc. 5.)

SUPPLEMENTARY PROCEEDINGS OF BOARD OF OFFICERS UPON THE COLE SYSTEM OF RIFLING.

SPRINGFIELD ARMORY, MASS., *June 14, 1902.*

The board met at 10 o'clock a. m. Present, Maj. John E. Greer, Maj. John Pitman, Capt. John T. Thompson, Ordnance Department.

The board then proceeded to consider the firings which have been conducted from time to time, in accordance with the resolution given on page 4 of its last report, dated Springfield Armory, Mass., December 14, 1901.

These firings have been made with the Springfield magazine rifle, 2,300 feet per second, with barrels rifled with the four service grooves, but of different twists, in comparison with a 2-grooved or Cole system barrel of 8-inch twist. All these barrels were otherwise of the model adopted for the Springfield magazine rifle.

Barrels with service grooves having the following twists were used:

3 with 8-inch twist.
3 with 9-inch twist.
2 with 10-inch twist.

All the barrels mentioned above were fired at 500 yards range, and all but the 9-inch twist at the 1,000 yards range. The results are given in the following table:

2,300 feet per second S. M. V.

Date.	Range.	No. of targets.	Rifling.		Service deviation.			Cole deviation.		
			Service.	Cole.	M. V.	M. H.	M. A.	M. V.	M. H.	M. A.
1902. March 1	500	7	10″ twist No. 1		3.5	3.5	5.06			
	500	7		8″ twist No. 1				3.9	3.7	5.47
April 1	500	9	8″ twist No. 1		5.7	4.4	7.3			
	500	9		8″ twist No. 1				3.4	4.1	5.4
April 19 and 21	500	8	8″ twist		4.4	5.2	6.9			
	500	8		8″ twist No. 1				3.2	4.5	5.6
April 23	500	8	10″ twist No. 1		3.3	3.6	5.8			
	500	8		8″ twist No. 1				2.8	3.9	4.9
April 28 and May 3	500	8	10″ twist No. 2		3.8	4.0	5.6			
	500	8		8″ twist No. 1				3.3	3.4	4.8

at an angle of 45° with the line of sight, the object being seen through a slit in the paper.

This instrument can be successfully used only by persons of good eyesight and whose eyes are approximately equal in strength.

As in all other observing instruments, practice necessarily increases the observer's facility and accuracy. It is claimed that the minimum angle of convergence may, by practice with excellent eyesight, be reduced from $\theta = 30''$ to $\theta = 10''$. This would divide the errors in the table by three.

Examining the foregoing table, it is seen that, if as accurate as described, the portable model No. I might be of use with infantry. Model No. II would be quite advantageous with light artillery by giving instantly a trial range. Model No. III is 5 feet long and probably would not stand the rough travel with light artillery, but if it can, it is better and simpler than anything now in use in our service. Model No. III is within the required limits of accuracy at midrange (2,000 yards) for seacoast artillery, but its error is too great for greater distances to allow its use as a range finder for the guns. It might be useful in observing the point of fall of the projectile in rapid fire.

As the details of construction are not known, it is impossible to state whether a greater value than 144 cm. may be given to B without loss of accuracy, but if B may be increased to 288 cm., the errors would be within the recognized limits of accuracy for seacoast artillery. If the magnification may be increased without too much loss of light, the same result may be obtained in that way. These and several other questions of accuracy and durability can be determined only by experimenting with the instrument. This could be done at the Artillery School at Fort Monroe, Va.

A cut of model No. I stereoscopical range finder is shown in fig. 5.

Very respectfully,

HENRY C. DAVIS,
Captain, Seventh Artillery.

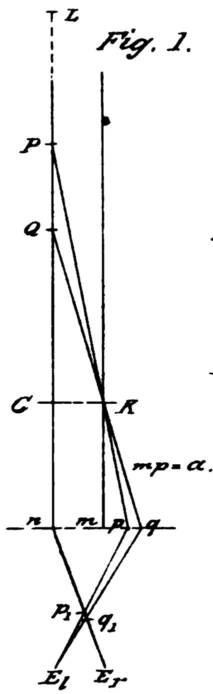


Fig. 1.

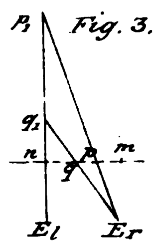


Fig. 3.

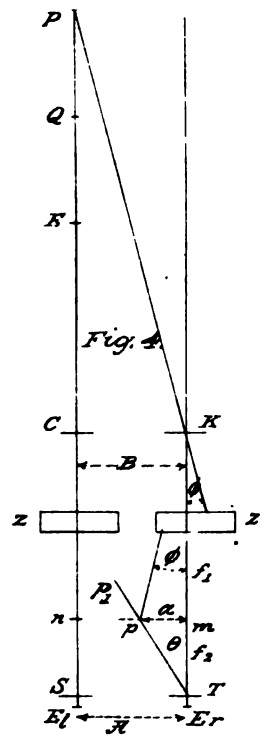


Fig. 4.

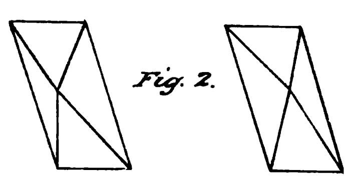
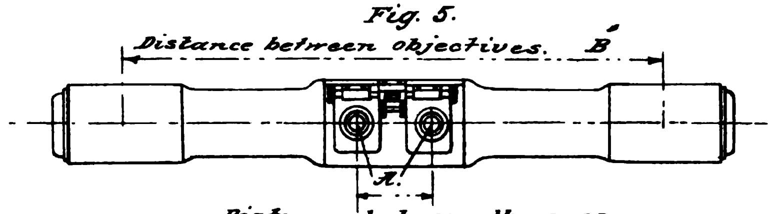


Fig. 2.

Fig. 5.



Appendix XII.

TEST OF COLE ELLIPTICAL BORE RIFLE.

WASHINGTON, D. C., *July 16, 1901.*

DEAR SIR: I have invented a gun with elliptical bore of .30 caliber, suitable to take the ordinary fixed ammunition of this caliber. I desire to have a thorough Government test, such as will demonstrate the quality of the gun for service. I desire to have the test made at the earliest convenience in order that I may be present.

Very respectfully,

W. F. COLE, M. D.

Gen. A. R. BUFFINGTON,
Chief of Ordnance, U. S. Army.

[First indorsement.]

OFFICE OF CHIEF OF ORDNANCE,
Washington, July 16, 1901.

Respectfully referred to the commanding officer, Springfield Armory, with instructions to test without delay the gun presented by Dr. Cole, who is authorized by this office to be present at such times during the test as he may desire.

A. R. BUFFINGTON,
Brigader-General, Chief of Ordnance.

[Second indorsement.]

SPRINGFIELD ARMORY, MASS., *July 18, 1901.*

Respectfully referred to the board of officers appointed by Post Orders, No. 43, of 1899, for immediate test.

FRANK H. PHIPPS,
Lieutenant-Colonel, Ordnance Department, U. S. Army, Commanding.

[Third indorsement.]

SPRINGFIELD ARMORY, MASS., *December 14, 1901.*

Respectfully returned to the commanding officer, Springfield Armory, with report herewith.

For the board.

JNO. E. GREER,
Ordnance Department, U. S. Army, President.

[Fourth indorsement.]

SPRINGFILLD ARMORY, MASS., *December 14, 1901.*

Respectfully returned to the Chief of Ordnance, U. S. Army; attention invited to the third indorsement hereon.

FRANK H. PHIPPS,
Lieutenant-Colonel, Ordnance Department, U. S. Army, Commanding.

REPORT ON DR. COLE RIFLE.

[Second indorsement on O. O. letter No. 36819.]

SPRINGFIELD ARMORY, MASS., *July 18, 1901.*

Respectfully referred to the board of officers appointed by Post Orders, No. 43, of 1899, for immediate test.

FRANK H. PHIPPS,
Lieutenant-Colonel, Ordnance Department, U. S. Army, Commanding.

SPRINGFIELD ARMORY, MASS., *December 14, 1901.*

The board, pursuant to the foregoing orders and indorsements, met at 1.30 p. m. July 18, 1901.

Present: Maj. John E. Greer, Ordnance Department, and Capt. Odus C. Horney, Ordnance Department.

Absent: Capt. Frank Baker, Ordnance Department, on leave per Ordnance Orders, No. 8, dated July 31, 1901, and Capt. John T. Thompson, sick in quarters.

Dr. W. F. Cole appeared before the board and presented for examination and test a caliber .30 rifle of his invention, having what he describes as an elliptical bore.

The length of the barrel of this rifle is the same as that of the service arm, 30 inches. The cross section of the bore is in the form of an ellipse, the short diameter being ".30, the long diameter ".31, and having a twist of one turn in 7".29.

Dr. Cole claimed for his gun greater accuracy and greater penetration than the ordinary rifle, the same ammunition being used in each.

In order to compare the accuracy of this rifle with the service rifle, firing was first conducted at 1,000 yards range with the following results:

Rifle.	Deviation.			Firer.
	Vert.	Hor.	Abs.	
Service (No. 326616)	31.34	11.67	33.4	R. T. Hare.
Do	24.40	11.88	27.1	Recorder.
Do	19.60	7.52	21.0	R. T. Hare.
Mean	25.11	10.36	27.2	
Cole	9.94	10.2	14.3	Do.
Do	8.90	12.0	14.9	Recorder.
Do	22.32	8.8	24.0	R. T. Hare.
Mean	13.72	10.3	17.7	

The penetration at this range was as follows:

Service—Mean of 5 rounds, 11.2 inches.
Cole—Mean of 5 rounds, 11 inches.

On the following day the test for accuracy was continued at 300 yards. As the results obtained with the service rifle at 1,000 yards on the preceding day were very unsatisfactory, a different rifle was used at this range. The results were as follows:

Rifle.	Deviation.			Firer.
	Vert.	Hor.	Abs.	
Service (No. 323821)	2.02	1.23	2.36	R. T. Hare.
Do	2.67	1.01	2.85	Do.
Mean	2.35	1.12	2.60	
Cole	2.94	2.23	3.69	Do.
Do	6.05	2.48	6.54	Do.
Do	6.69	3.45	7.53	Dr. Cole.
Mean	5.56	2.72	5.99	

Velocities at 53 feet from the muzzle were next taken, and found to be as follows:

Service rifle (mean of 5 rounds):
Old instrument reading, 1,971.91 feet per second.
New instrument reading, 1,991.55 feet per second.
Cole rifle (mean of 5 rounds):
Old instrument reading, 2,040.79 feet per second.
New instrument reading, 2,058.66 feet per second.

NOTE.—A cartridge said to be loaded to give a pressure of 46,000 pounds was fired at Dr. Cole's request from his rifle. The velocity obtained at 53 feet was 2,165.5 feet per second.

Dr. Cole, being obliged to return home, left his rifle with the board, to be subjected to such further tests as might be deemed necessary or desirable.

It will be seen from the firings up to this point that the results obtained with the Cole rifle were very promising, and it was decided that further firings would be conducted from time to time as it became necessary to conduct firings with service rifles. By this means data which would furnish a basis of comparison with the service rifle would be obtained more conveniently and economically than in any other way.

On July 23 firings were conducted at 1,000 yards, using the same rifle that was used at 300 yards. The results were as follows:

Rifle.	Deviation.			Firer.
	Vert.	Hor.	Abs.	
Service (No. 323821)	20	8.77	21.8	R. T. Hare.
Do	22.85	8.87	24.5	Do.
Do	16.8	7.2	18.3	Do.
Do	16.18	7.34	17.8	Do.
Mean	18.96	8.04	20.6	
Cole	14.74	4	15.2	Do.
Do	14.62	6.28	15.9	Do.
Do	22.62	5.78	23.4	Do.
Do	17.86	12.56	21.08	Do.
Mean	17.46	7.15	19.1	

On July 26 another series of shots was fired at 1,000 yards, the barrel of the service rifle used on July 18 at 1,000 yards being mounted on another stock with entirely new fittings. The results were as follows:

Rifle.	Deviation.			Firer.
	Vert.	Hor.	Abs.	
Service (No. 236616)	20.96	13.6	25	R. T. Hare.
Do	20.48	6.6	21.5	Do.
Do	13.92	15.08	21	Do.
Do	7.47	7.17	10.35	Do.
Mean	15.71	10.79	19.46	
Cole	17.86	12.42	21.8	Do.
Do	18.71	7.04	20	Do.
Do	21.06	7.42	22.3	Do.
Do	13.08	12.57	18.1	Do.
Mean	17.68	9.95	20.57	

On October 1 firings were conducted at 1,200 and 1,500 yards, with the following results:

At 1,200 yards.

Rifle.	Deviation.			Firer.
	Vert.	Hor.	Abs.	
Service (No. 323821)	36.5	25	44.2	R. T. Hare.
Do	21.6	11.1	24.3	Do.
Do	27.8	14	31.1	Do.
Mean	28.6	16.7	33.2	
Cole	23.5	15.9	28.4	Do.
Do	29.3	24.7	38.3	Do.
Do	17.8	19	26	Do.
Mean	23.5	19.9	30.9	
New model	24.6	25.1	35.1	Do.
Springfield rifle, 2,300 feet per second velocity	24.7	15.4	29.1	Do.
	21	15.5	26.1	Do.
Mean	23.1	18.7	30.1	

At 1,500 yards.

Rifle.	Deviation.			Firer.
	Vert.	Hor.	Abs.	
Service (No. 323821)	41.5	44.5	60.8	R. T. Hare.
Do	39.1	19.8	43.8	Do.
Mean	40.3	32.1	52.3	
Cole	28.2	35.6	43.8	Do.
Do	47.6	30.8	56.4	Do.
Mean	37.9	31.9	50.1	
New model	28.3	16.5	31.5	Do.
Springfield rifle, 2,300 feet per second velocity	27.6	35.3	44.3	Do.
Mean	27.9	25.9	37.9	

Before any further firings had been made, Dr. Cole made request that his rifle be returned to him, and this was done.

It will be seen by an examination of the preceding records of firings that the Cole rifle was less accurate than the service rifle at 300 yards, and, in general, slightly more accurate at longer ranges. The greater accuracy at long ranges would seem to indicate greater steadiness of the bullet in flight, but just how much of this increased steadiness is due to the system of rifling and how much to the sharper twists used in the Cole gun can not be determined by the limited number of firings thus far conducted; and a barrel for use in the service rifle has been rifled on the Cole system and a further series of firings is contemplated.

It is thought that the subject is worth thorough investigation, and positive conclusions can be drawn only after a large number of records have been made and examined. When the board shall have completed such a number of experiments as to enable it to form definite conclusions, further report upon the subject will be made.

John E. Greer,
Major, Ordnance Department, U. S. Army, President.
Jno. T. Thompson,
Captain, Ordnance Department, U. S. Army.
Odus C. Horney,
Captain, Ordnance Department, U. S. Army, Recorder.

Captain Baker, not having witnessed any part of this test, does not sign the report.

Approved, and respectfully forwarded for the information of the Chief of Ordnance, U. S. Army. Orders have been given for an exhaustive series of firings with a barrel rifled after Dr. Cole's plan, to ascertain if it possesses merit over our present system. If so, riflings of different lengths of twist will be tried to see which is best suited to the new rifle. The Cole system, if successful, will relieve, it is thought, any apprehension of jacket strippings of the bullet, and may admit of the use of a lead bullet giving a higher sectional density.

FRANK H. PHIPPS,
Lieutenant-Colonel, Ordnance Department,
U. S. Army, Commanding.

SPRINGFIELD ARMORY, MASS.,
December 14, 1901.

(36819—Enc. 5.)

SUPPLEMENTARY PROCEEDINGS OF BOARD OF OFFICERS UPON THE COLE SYSTEM OF RIFLING.

SPRINGFIELD ARMORY, MASS., *June 14, 1902.*

The board met at 10 o'clock a. m. Present, Maj. John E. Greer, Maj. John Pitman, Capt. John T. Thompson, Ordnance Department.

The board then proceeded to consider the firings which have been conducted from time to time, in accordance with the resolution given on page 4 of its last report, dated Springfield Armory, Mass., December 14, 1901.

These firings have been made with the Springfield magazine rifle, 2,300 feet per second, with barrels rifled with the four service grooves, but of different twists, in comparison with a 2-grooved or Cole system barrel of 8-inch twist. All these barrels were otherwise of the model adopted for the Springfield magazine rifle.

Barrels with service grooves having the following twists were used:

3 with 8-inch twist.
3 with 9-inch twist.
2 with 10-inch twist.

All the barrels mentioned above were fired at 500 yards range, and all but the 9-inch twist at the 1,000 yards range. The results are given in the following table:

2,300 feet per second S. M. V.

Date.	Range.	No. of targets.	Rifling.		Service deviation.			Cole deviation.		
			Service.	Cole.	M. V.	M. H.	M. A.	M. V.	M. H.	M. A.
1902. March 1....	500	7	10″ twist No. 1.	....	3.5	3.5	5.06	......	......	......
	500	7	....	8″ twist No. 1.	......	......	......	3.9	3.7	5.47
April 1.....	500	9	8″ twist No. 1..	....	5.7	4.4	7.3	......	......	......
	500	9	....	8″ twist No. 1.	......	......	......	3.4	4.1	5.4
April 19 and 21.	500	8	8″ twist.......	....	4.4	5.2	6.9	......	......	......
	500	8	....	8″ twist No. 1.	......	......	......	3.2	4.5	5.6
April 23....	500	8	10″ twist No. 1.	....	3.3	3.6	5.8	......	......	......
	500	8	....	8″ twist No. 1.	......	......	......	2.8	3.9	4.9
April 28 and May 3	500	8	10″ twist No. 2.	....	3.8	4.0	5.6	......	......	......
	500	8	....	8″ twist No. 1.	......	......	......	3.3	3.4	4.8

2,300 feet per second S. M. V.—Continued.

Date.	Range.	No. of targets.	Rifling.		Service deviation.			Cole deviation.		
			Service.	Cole.	M. V.	M. H.	M. A.	M. V.	M. H.	M. A.
1902.										
May 13 and 15.	500	8	9″ twist No. 1		4.1	4.0	5.9			
	500	8		8″ twist No. 2				3.6	4.1	5.6
May 15 and 16.	500	8	9″ twist No. 2		4.2	4.5	6.3			
	500	8		8″ twist No. 2				4.5	4.0	6.1
May 16 and 31.	500	8	9″ twist No. 3		3.4	4.1	5.4			
	500	8		8″ twist No. 2				3.2	3.5	4.8
June 2 and 3	500	8	8″ twist No. 2		4.5	3.0	5.5			
	500	8		8″ twist No. 2				2.8	3.0	4.2
	500	8	8″ twist No. 3		3.8	3.4	5.3			
Mean of 80 targets for service					4.07	3.97	5.906			
Mean of 72 targets for Cole								3.41	3.8	5.21
1902.										
February 13	1,000	4	10″ twist No. 1		11.5	15.1	19.3			
	1,000	4		8″ twist No. 1				12.5	13.1	18.45
February 27	1,000	5	10″ twist No. 2		11.2	8.5	14.2			
	1,000	5		8″ twist No. 1				12.8	7.7	14.4
April 19 and 21.	1,000	6	8″ twist No. 1		10.9	8.8	14.8			
	1,000	6		8″ twist No. 1				9.4	7.5	12.2
April 22, 25, and 28.	1,000	9	10″ twist No. 1		12.9	13.6	19.0			
	1,000	9		8″ twist No. 1				11.3	12.1	17.0
May 5 and 13.	1,000	6	10″ twist No. 2		9.9	11.4	16.1			
	1,000	6		8″ twist No. 1				7.7	9.2	12.2
June 4 and 5	1,000	8	8″ twist No. 3		10.0	10.9	15.0			
	1,000	8		8″ twist No. 2				8.3	10.4	13.7
	1,000	8	8″ twist No. 2		8.9	11.0	14.7			
Mean of 46 targets for service					10.76	11.33	16.16			
Mean of 38 targets for Cole								10.33	10.0	14.66

Examination of this table will show that except in two cases the Cole system of rifling has proved superior to the service system.

The best records were made on June 2 and 3, 1902, but the weather was rather better at that time than during preceding tests. The 8-inch twist gave better results on these days than the others on preceding days, but taking the records of the three 8-inch twist 4-grooved barrels at 500 yards: 7″.3, 6″.9, 5″.5, and 5″.3, the average deviation is 6″.2, as against 5″.1 for the Cole rifling on the same days, a difference in favor of the Cole of 1″.1.

At the 1,000 yards range the advantage of the Cole 8-inch twist over the service 8-inch twist is 14″.83−12″.95=1″.88. This is a mean of 22 targets for the 4-grooved barrels and of 14 targets for the 2-grooved Cole barrel.

The firing was necessarily slow, owing to the fact that but one Springfield magazine rifle was available, and it had to be completely dismounted several times a day, the barrel being removed and replaced by another.

There remain the three 9-inch twist barrels to be fired at 1,000 yards, but, judging from past experience, it is doubtful if anything will be gained by so doing. The pressure of the 2,300 feet per second service cartridge in the Cole barrel is practically the same as that in the 4-grooved service barrel.

It may be that the superiority shown by the 2-grooved or Cole rifling is due to the escape of gas in the 4-grooved barrel past the bullet, owing to too small diameter of the latter.

It seems safe to say that the 2-grooved or Cole system is preferable to the service system, and the board therefore recommends that a number—500 or more—barrels be so rifled and be assembled with the first Springfield magazine rifles manufactured. Suitable tests by marksmen in the service and at the armory can be then advantageously made.

There being no further business before it, the board then adjourned to meet at the call of its president.

JOHN E. GREER,
Major, Ordnance Department, U. S. Army, President.
J. PITMAN,
Major, Ordnance Department, U. S. Army.
JNO. T. THOMPSON,
Captain, Ordnance Department, U. S. Army, Recorder.

SPRINGFIELD ARMORY, MASS., *June 26, 1902.*

Proceedings and recommendation approved. The system of elliptical rifling is not new, but was presented over forty years ago.

FRANK H. PHIPPS,
Lieutenant-Colonel, Ordnance Department,
U. S. Army, Commanding.

(36819—1 Enc. 2.)

PROCEEDINGS OF A BOARD OF OFFICERS CONVENED BY THE FOLLOWING ORDER AND INDORSEMENTS:

POST ORDERS, No. 6. SPRINGFIELD ARMORY, MASS., *February 1, 1902.*

* * * * * * *

V. A board of officers is hereby appointed to meet at this armory from time to time to consider and report upon such inventions and devices as the commanding officer may submit to it. Detail for the board: Maj. John E. Greer, Ordnance Department; Maj. John Pitman, Ordnance Department; Capt. John T. Thompson, Ordnance Department.

FRANK H. PHIPPS,
Lieut. Colonel, Ord. Dept., U. S. A., Commanding.

(36819—Enc. 1.)

[Fifth indorsement.]

OFFICE OF THE CHIEF OF ORDNANCE,
Washington, July 14, 1902.

Respectfully referred to the commanding officer, Frankford Arsenal, inviting attention to the supplementary report of the board on the elliptical-bore rifle at Springfield Armory, dated June 14, 1902. It is stated that the superiority shown by this system may be due to the escape of gas in the 4-groove barrel past the bullet. In view of the improvements made in the caliber .30 rifle bullet by expansion of base to the diameter of 0.308 by swaging or cupping of metal by a conical punch (see 30024–B–236, Encs. 1–3), it is desired to ascertain whether the superiority of the elliptical bore will hold good using the improved bullet.

He is therefore instructed to furnish the commanding officer, Springfield Armory, with sufficient of the improved ammunition to make the comparative trials desired. That officer is instructed to repeat the firings with the two systems, using the improved ammunition, and report results to this office.

36819, 36819–Enc. 2, 36819–Enc. 3, 36819–Enc. 5, 36819–1–Enc. 2, and 36819–11 of this Ordnance Office file are herewith. Duplicate copy of supplementary report has been retained in this office.

WILLIAM CROZIER,
Brigadier-General, Chief of Ordnance.

[Sixth indorsement.]

FRANKFORD ARSENAL, PA., *July 18, 1902.*

Respectfully returned to the Chief of Ordnance, U. S. Army, through the commanding officer, Springfield Armory.

Three thousand rounds of ammunition, caliber .30, with improved bullet, were this day shipped to Springfield Armory by express.

FRANK HEATH,
Major, Ordnance Department, U. S. Army, Commanding.

[Seventh indorsement.]

SPRINGFIELD ARMORY, MASS., *July 19, 1902.*

Respectfully referred to the board of officers appointed by Post Orders, No. 6, current series, which will, upon receipt of the ammunition referred to in sixth endorsement hereon, repeat the firings heretofore made with the Cole and 4-groove systems of rifling, reporting results.

FRANK H. PHIPPS,
Lieutenant-Colonel, Ordnance Department, U. S. Army, Commanding.

SPRINGFIELD ARMORY, MASS., *August 5, 1902.*

The board met at 10 a. m. Present, all the members.

The board then examined the results of the firings made in accordance with instructions contained in the above endorsements, which are as follows:

Trial of cupped-base bullets, M. V. 2,000 feet, fired from service rifles with Cole barrels, 10-inch twist, in comparison with the regular service rifles, 10-inch twist.

JULY 26 TO 29, 1902.

Rifle.	Range.	Elevation.	Deviation.			Remarks.
			M. V.	M. H.	M. A.	
Cole barrel, 10" twist:	*Yards.*	*Yards.*	*Inches.*	*Inches.*	*Inches.*	These targets fired alternately with service barrels, 10" twist. Weather and light good. Wind, from calm to stiff breeze from 9.30 to 12 o'clock in direction. Fired by R. T. Hare and F. R. Bull.
No. 364703	500	500	3.3	3.5	4.8	
No. 364427	500	500	8.1	3.7	8.9	
No. 364050	500	500	4.5	3.3	5.6	
No. 364541	500	500	6.3	6.0	8.7	
No. 364703	500	500	5.1	4.5	6.8	
No. 364427	500	500	7.1	5.0	8.7	
No. 364050	500	500	4.5	2.2	5.0	
No. 364541	500	500	6.2	3.3	7.0	
No. 364703	500	500	4.2	4.6	6.2	
No. 364427	500	500	6.3	4.4	7.7	
No. 364050	500	500	4.6	3.7	5.9	
No. 364541	500	500	4.8	4.4	6.5	
No. 364703	500	500	5.3	3.6	6.4	
No. 364427	500	500	6.7	2.2	7.0	
No. 364050	500	500	4.5	5.5	7.1	
No. 364541	500	500	3.0	5.0	5.9	
No. 364703	500	500	7.1	3.0	7.7	
No. 364427	500	500	6.1	3.9	7.3	
No. 364050	500	500	8.2	4.7	9.5	
No. 364541	500	500	5.4	3.9	6.7	
Mean of 20 targets			5.6	4.0	7.0	

Trial of cupped-base bullets, M. V. 2,000 feet, fired from regular service rifles, 10-inch twist, in comparison with Cole barrels in service rifles.

JULY 26 TO 29, 1902.

Rifle.	Range.	Elevation.	Deviation.			Remarks.
			M. V.	M. H.	M. A.	
Service barrel, 10″ twist:	*Yards.*	*Yards.*	*Inches.*	*Inches.*	*Inches.*	These targets were fired alternately with Cole barrel, 10″ twist. Weather and light good. Wind, from calm to stiff breeze from 9.30 to 12 o'clock in direction. Fired by R. T. Hare and F. R. Bull.
No. 399390	500	500	9.5	3.2	10.0	
No. 400586	500	500	4.7	4.6	6.6	
No. 400888	500	500	4.9	3.9	6.3	
No. 400638	500	500	5.3	5.2	7.4	
No. 399390	500	500	8.1	2.4	8.4	
No. 400586	500	500	5.5	4.4	7.0	
No. 400888	500	500	7.5	3.1	8.1	
No. 400638	500	500	4.5	3.4	5.6	
No. 399390	500	500	6.5	3.4	7.3	
No. 400586	500	500	6.4	4.3	7.7	
No. 400888	500	500	5.0	4.6	6.8	
No. 400638	500	500	6.1	4.9	7.8	
No. 399390	500	500	4.8	3.2	5.8	
No 400586	500	500	5.8	4.5	7.3	
No. 400888	500	500	6.2	4.0	7.4	
No. 400638	500	500	5.9	3.0	6.6	
No. 399390	500	500	4.6	3.3	5.7	
No. 400586	500	500	4.9	4.0	6.4	
No. 400888	500	500	6.0	4.9	7.7	
No. 400638	500	500	6.0	3.2	6.8	
Mean of 20 targets	....	....	5.9	3.9	7.1	

Trial of cupped-base bullets, M. V. 2,000 feet, fired from service rifles with Cole barrel, 10-inch twist, in comparison with the regular service rifle, 10-inch twist.

AUGUST 1 TO 4, 1902.

Rifle.	Range.	Elevation.	Deviation.			Remarks.
			M. V.	M. H.	M. A.	
Cole barrel, 10″ twist:	*Yards.*	*Yards.*	*Inches.*	*Inches.*	*Inches.*	These targets fired alternately with service barrel, 10″ twist. Weather and light good. Wind from light to strong breeze, about 10 to 12 o'clock in direction. Fired by R. T. Hare and F. R. Bull.
No. 364703	1,000	975	25.2	7.0	26.2	
No. 364427	1,000	975	11.4	8.3	14.1	
No. 364050	1,000	975	12.8	5.8	14.0	
No. 364541	1,000	975	20.6	5.6	21.4	
No. 364703	1,000	975	25.0	9.1	26.6	
No. 364427	1,000	975	16.1	14.0	21.4	
No. 364050	1,000	975	21.1	12.0	24.2	
No. 364541	1,000	975	20.6	8.3	22.2	
No. 364703	1,000	975	15.9	13.1	20.6	
No. 364427	1,000	975	19.4	10.7	22.2	
No. 364050	1,000	975	19.6	10.9	22.4	
No. 364541	1,000	975	11.3	9.3	14.6	
No. 364703	1,000	975	8.7	11.7	14.6	
No. 364427	1,000	975	11.5	13.2	17.5	
No. 364050	1,000	975	11.9	7.3	13.9	
No. 364541	1,000	975	12.8	10.1	16.0	
No. 364703	1,000	975	21.1	4.6	21.6	
No. 364427	1,000	975	12.1	10.3	15.9	
No. 364050	1,000	975	7.4	11.6	13.8	
No. 364541	1,000	975	7.1	19.1	20.4	
Mean of 20 targets	....	....	15.6	10.1	19.2	

Trial of cupped-base bullet, M. V. 2,000 feet, fired from the regular service rifle, 10-inch twist, in comparison with Cole barrels, 10-inch twist, in service rifle.

AUGUST 1 TO 4, 1902.

Rifle.	Range.	Elevation.	Deviation.			Remarks.
			M. V.	M. H.	M. A.	
Service barrel, 10″ twist:	Yards.	Yards.	Inches.	Inches.	Inches.	
No. 399390	1,000	1,000	18.9	8.7	20.8	These targets fired alternately with Cole barrel, 10″ twist. Weather and light good. Wind from light to strong breeze, from 10 to 12 o'clock in direction. Fired by R. T. Hare and F. R. Bull.
No. 400586	1,000	1,000	21.5	9.4	21.2	
No. 400888	1,000	1,000	23.9	11.0	26.3	
No. 400638	1,000	1,000	20.8	8.1	22.3	
No. 399390	1,000	1,000	21.8	9.0	23.6	
No. 400586	1,000	1,000	27.7	9.7	29.4	
No. 400888	1,000	1,000	23.6	12.2	26.6	
No. 400638	1,000	1,000	19.1	7.8	20.6	
No. 399390	1,000	1,000	19.3	10.5	22.0	
No. 400586	1,000	1,000	16.3	8.4	18.4	
No. 400888	1,000	1,000	16.4	17.6	24.0	
No. 400638	1,000	1,000	20.3	7.3	21.6	
No. 399390	1,000	1,000	26.5	23.6	35.5	
No. 400586	1,000	1,000	30.3	19.5	36.0	
No. 400888	1,000	1,000	29.4	21.7	36.5	
No. 400638	1,000	1,000	21.7	4.3	22.1	
No. 399390	1,000	1,000	12.9	8.4	15.4	
No. 400586	1,000	1,000	20.5	7.1	21.7	
No. 400888	1,000	1,000	29.8	11.5	32.0	
No. 400638	1,000	1,000	25.1	10.1	27.1	
Mean of 20 targets			22.3	11.3	25.2	

Test of Cole 8-inch twist and service 8-inch twist barrels, with new cupped bullet, in new magazine rifle No. 2.

JULY 31, 1902.

Rifle.	Range.	Elevation.	Deviation.			Remarks.
			M. V.	M. H.	M. A.	
New magazine rifle No. 2:	Yards.		Inches.	Inches.	Inches.	
Cole barrel, 8″ twist.	500	Mark on base.	7.2	3.2	7.9	Weather and light good, almost calm. Fired by R. T. Hare and F. R. Bull.
Do	500	.....do	4.0	2.2	4.5	
Do	500	.....do	3.6	2.8	4.5	
Do	500	.....do	4.2	3.5	5.4	
Do	500	.....do	4.1	3.6	5.4	
Mean			4.6	3.1	5.5	
Service barrel, 8″ twist	500	Mark on base.	7.8	3.9	8.7	Ammunition, cupped bullet, W. A. tubular powder. Barrels changed after second target. In this test the bullets of some of the cartridges for the new magazine rifle were replaced by cupped bullets taken from the cartridges sent from Frankford Arsenal.
Do	500	.....do	6.5	3.8	7.5	
Do	500	.....do	2.6	2.4	3.6	
Do	500	.....do	4.5	4.1	6.1	
Do	500	.....do	5.5	6.1	8.2	
Mean			5.4	4.1	6.8	

Test of Cole 8-inch twist and service 8-inch twist barrels, with new cupped bullet, in new magazine rifle No. 2.

JULY 31, 1902.

Rifle.	Range.	Elevation.	Deviation. M. V.	Deviation. M. H.	Deviation. M. A.	Remarks.
New magazine rifle No 2:	*Yards.*	*Yards.*	*Inches.*	*Inches.*	*Inches.*	
Cole barrel, 8" twist.....	1,000	875	6.9	9.7	11.9	Weather and light good, very strong breeze; 12 o'clock in direction. Fired by R. T. Hare and F. R. Bull.
Do....................	1,000	875	9.9	12.0	15.6	
Do....................	1,000	875	7.9	13.0	15.2	
Do....................	1,000	875	6.7	11.9	13.7	
Do....................	1,000	875	5.9	8.6	10.4	
Mean..................	....	....	7.5	11.0	13.4	
Service barrel, 8" twist..	1,000	875	8.6	27.9	29.2	Ammunition, cupped bullet, W. A. tubular powder.
Do....................	1,000	875	9.4	9.9	13.7	
Do....................	1,000	875	12.4	15.3	19.7	
Do....................	1,000	875	9.4	13.2	16.2	
Do....................	1,000	875	10.1	15.2	18.3	
Mean..................	....	....	10.0	16.3	19.4	

The foregoing results show that the superiority of the elliptical bore does hold good with the cupped bullet.

There being no further business before it, the board adjourned to meet at the call of its president.

JOHN E. GREER,
Lieutenant-Colonel, Ordnance Department, U. S. Army,
President.

J. PITMAN,
Major, Ordnance Department, U. S. Army.

JNO. T. THOMPSON,
Captain, Ordnance Department, U. S. Army,
Recorder.

SPRINGFIELD ARMORY, MASS.,
August 9, 1902.

Approved and respectfully forwarded to the Chief of Ordnance, U. S. Army, Washington, D. C.

With these rifles, using ammunition giving 2,000 feet velocity, at 500 yards the targets made with the Cole barrel and the service barrel were practically the same. At 1,000 yards, however, there is a marked difference in favor of the Cole barrel.

In the firings with the new magazine rifle No. 2, giving 2,300 feet velocity, at both 500 and 1,000 yards the Cole barrel gave the best results.

FRANK H. PHIPPS,
Lieutenant-Colonel, Ordnance Department, U. S. Army,
Commanding.

(36819—1 Enc. 3.)

[Twelfth indorsement.]

OFFICE OF THE CHIEF OF ORDNANCE,
Washington, August 23, 1902.

Respectfully returned to the commanding officer Springfield Armory. * * * Further report desired as to results of test of new ammunition, Cole's design in altered rifle, and results of endurance tests ordered August 7, as soon as completed.

By order of the Chief of Ordnance:

W. W. GIBSON,
Captain, Ordnance Department, U. S. Army.

[Thirteenth indorsement.]

SPRINGFIELD ARMORY, MASS.,
September 6, 1902.

Respectfully returned to the Chief of Ordnance, U. S. Army, with report that no further extended firings have been made with the rifle of Dr. Cole's design. If the test for endurance is to be made it involves the commencement of another test with new barrels. Before this is done it is requested that this paper be referred to Captain Lissak for a report as to the results of firing at Seagirt with rifling of 8-inch twist and that of Dr. Cole's design. The reports that have reached me are such as to lead me to understand that the service gun with 8-inch twist was preferred and that its shooting was equally good. If such is the case the expense of further tests would not seem necessary.

FRANK H. PHIPPS,
Lieutenant-Colonel, Ordnance Department, U. S. Army, Commanding.

[Fourteenth indorsement.]

OFFICE OF THE CHIEF OF ORDNANCE,
Washington, September 12, 1902.

Respectfully returned to the commanding officer Frankford Arsenal for remark.
By order of the Chief of Ordnance:

C. C. WILLIAMS,
Captain, Ordnance Department, U. S. Army.

[Fifteenth indorsement.]

FRANKFORD ARSENAL, PA., *September 15, 1902.*

Respectfully returned to the Chief of Ordnance, U. S. Army, with an extract of the report of Captain Lissak of his observations at Fort Sheridan and Seagirt, which has reference to the two rifles referred to in the thirteenth indorsement. It will be seen that, while the results with Dr. Cole's rifle were inferior to those with the 8-inch twist rifle, it was thought that a final opinion on their relative merits could not be formed from the tests of a single rifle of each kind.

FRANK HEATH,
Major, Ordnance Department, U. S. Army, Commanding.

EXTRACT FROM REPORT OF CAPTAIN LISSAK ON HIS OBSERVATIONS AT FORT SHERIDAN AND SEAGIRT.

* * * * * * *

THE NEW SPRINGFIELD MAGAZINE RIFLE.

Two of these rifles were sent to me at Seagirt, one fitted with a barrel with rifling the same as in the present service rifle and one fitted with a Cole barrel. These arms excited great interest among the riflemen on the range. They examined them carefully, discussed their various features, and expressed great pleasure that the opportunity was afforded them to examine and try the rifles before they were issued by the Department.

The most expert of the marksmen were glad to do the firing necessary for the comparative test of the two systems of rifling. All who fired either of the guns made report that it was a superior weapon to the present service rifle. Their approval of the arm and their conviction as to its superiority over the present arm was so marked that the permission of the Chief of Ordnance was asked and obtained to use the rifles in the coming international rifle match to be held in Canada.

The following criticisms were made:

Butt plate.—Complaint is made that the straight form of butt plate and its sharp edges hurt the shoulder, particularly when firing in the prone position. A curved butt plate, roughened to prevent slipping, is preferred.

Trigger pull.—Objection is made to the "creep" of the trigger after the lost motion is taken up and before the firing pin is released. The most desirable trigger movement appeared to be one which permits no motion of the trigger after the lost motion is taken up until the full pressure required for firing is exerted by the finger. The lost motion allows the trigger to be felt and pressed without danger of accidental discharge, and the discharge of the piece occurring immediately upon any further

movement of the trigger enables the marksman to fire at the instant that he has his gun pointed as desired.

Rear sight.—The change of shape of roughened button on clamp is an advantage, likewise the addition of the friction spring holding the fixed and movable bases in closer contact. The remarks made as to the screw for windage on the rear sight of the Krag-Jörgensen rifle apply here also.[a] (Frequently can not be unclamped in changing windage, by pressure of the finger, but requires a blow, usually given with the head of a cartridge. Movable base of sight too loose, and when unclamped to change windage frequently former windage is lost before corrected. Screws fastening new sights to old guns work loose. The former Buffington sight, in which the windage is changed by the motion of a screw, is greatly preferred by marksmen in general. The advantage of being able to change quickly and certainly and by a definite amount, and without possibility of losing or forgetting the former setting of the sight while the change is being made, is a strong recommendation in favor of that form of sight.)

Trigger guard.—Should be large enough to admit two fingers of the marksman.

Bolt handle.—This lies closer to the stock than in the Krag-Jörgensen rifle, and is farther forward with respect to the trigger, so that it is little liable to be raised by the marksman's finger.

Lower band.—Securing pin does not hold when gun sling is used in firing. Band screw works loose.

Upper band.—Works forward, and presses in ramrod stop, releasing rod.

Ramrod bayonet.—The utility of the ramrod bayonet as a bayonet, and the need for such an adjunct to the arm, were much questioned. Used as a cleaning rod, the shoulders of the grooves for ramrod stop will be likely to mar the muzzle edge of the rifling, and thus injuriously affect the accuracy of the arm.

Sights.—The mounting of the sights on independent bands is considered a marked improvement.

Clip.—The single clip that was sent to Seagirt was used many times in showing the rifles, and worked satisfactorily.

Firings were made with the rifles as follows:

Range	200 yards.		600 yards.		1,000 yards.	
Rifling	Service.	Cole.	Service.	Cole.	Service.	Cole.
Number shooting	4	4	2	2	14	15
Number of shots	40	40	15	15	178	161
Total of scores	171	178	67	65	605	450
Average per shot	4.27	4.45	4.47	4.33	3.40	2.80

At 200 and 600 yards there were very few hits below 4 in value, and no apparent difference in the accuracy of the two rifles, the difference in the scores being due principally to the varying number of shots required to determine the proper position of the rear sight for the individual marksman.

At 1,000 yards much better results were obtained with the service rifling, and most of the marksmen who used both guns pronounced in favor of the arm so rifled. As individual rifles of the same pattern differ materially in accuracy, a test of one weapon of each kind is hardly sufficient to determine between two different systems.

Of the 14 scores of 8 or more shots each fired at 1,000 yards from the gun with service rifling, 10 contained misses, 4 no misses; of the 15 scores fired from the Cole barrel, 12 contained misses and 3 no misses.

*　*　*　*　*　*　*

(36819—1 Enc. 4.)

[Sixteenth indorsement.]

Office of the Chief of Ordnance,
Washington, September 19, 1902.

Respectfully returned to the commanding officer, Springfield Armory, for remark.

By order of the Chief of Ordnance:

W. W. Gibson,
Captain, Ordnance Department, U. S. Army.

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[a] The remarks following, inclosed in parentheses, are taken from the report pertaining to Krag-Jörgensen rifle.

[Seventeenth indorsement.]

SPRINGFIELD ARMORY, MASS., *September 23, 1902.*

Respectfully returned to the Chief of Ordnance, U. S. Army. It would probably be more satisfactory to Dr. Cole, and to the Department also, to have settled at this time the relative merits of the 8-inch service twist and the elliptical groove suggested by Dr. Cole. To do this further experiments should be made with the new rifle, using 2,300 feet velocity cartridges and the bullet to be adopted for this new rifle. If such a test is approved, two new barrels will be made representing the two systems, and firings will be made with them for accuracy and for endurance, testing the wear of the rifling. For this purpose 10,000 cartridges should be furnished from Frankford Arsenal—5,000 for each gun.

FRANK H. PHIPPS,
Lieutenant-Colonel, Ordnance Department, U. S. Army, Commanding.

[Eighteenth indorsement.]

OFFICE OF THE CHIEF OF ORDNANCE,
Washington, September 29, 1902.

Respectfully returned to the commanding officer, Springfield Armory. The experiments with the elliptical-groove system (Cole's) should be discontinued. Dr. Cole has been informed that the Department does not consider that it possesses sufficient advantages over present system to warrant further experiments. * * *

WILLIAM CROZIER,
Brigadier-General, Chief of Ordnance.

APPENDIX XIII.

TEST OF LATEST MODEL MAUSER AUTOMATIC PISTOL.

NEW YORK, *April 19, 1902.*

DEAR SIR: Referring to some correspondence we had with your department on October 3, 1901, regarding a test of our Mauser automatic pistol or carbine, we have the honor to report that such a test was made at Springfield on April 7, 8, and 9. We would respectfully ask whether your department would not be willing to purchase a number of such weapons for a practical test with the troops, such as are made with several similar pistols, providing the tests were considered satisfactory by your authorities. Should your department feel interested in having a number of the various samples of the Mauser pistol or carbine submitted to you, we should be pleased to take a run out to Washington, and as young Mr. Mauser, the nephew of the inventor, is with us at present, Mr. Mauser would be pleased to accompany us and give you all possible information and illustration of the arm. As Mr. Mauser expects to leave for Europe within a reasonably short time, we would feel much obliged for a reply from your department.

Very respectfully,

VON LEUGERKE & DETWOLD.

ADJUTANT-GENERAL, U. S. ARMY,
Washington, D. C.

[First indorsement.]

OFFICE OF THE CHIEF OF ORDNANCE,
Washington, April 23, 1902.

Respectfully referred to the commanding officer, Springfield Armory, for remark.

By order of the Chief of Ordnance:

W. W. GIBSON,
Captain, Ordnance Department, U. S. Army.

[Second indorsement.]

SPRINGFIELD ARMORY, MASS., *April 26, 1902.*

Respectfully returned to the Chief of Ordnance, U. S. Army, inviting attention to report of board of officers this day forwarded, which recommends a purchase of a few of the Mauser automatic pistols for trial in the field. As there are some officers who claim great advantages for this pistol, it is considered well that they should be allowed to try it in comparison with other patterns; but especial attention is invited to the caliber of this and the Luger pistols as compared with that of the Colt automatic pistol, which has been fixed by the department at 0.38 inch. There would be a fairer comparison of the Mauser and Luger pistols with the Colt pistol if the former were of the same caliber, 0.38 inch.

FRANK H. PHIPPS,
Lieutenant-Colonel, Ordnance Department, U. S. Army, Commanding.

Proceedings of a board of officers convened by the following order:

POST ORDERS, No. 6.

SPRINGFIELD ARMORY, MASS.,
February 1, 1902.

* * * * * * *

V. A board of officers is hereby appointed to meet at this armory from time to time to consider and report upon such inventions and devices as the commanding

officer may submit to it. Detail for the board: Maj. John E. Greer, Maj. John Pitman, Capt. John T. Thompson, Ordnance Department.

FRANK H. PHIPPS,
Lieutenant-Colonel, Ordnance Department, U. S. Army, Commanding.

SPRINGFIELD ARMORY, MASS.,
April 23, 1902.

The board convened, pursuant to the foregoing order, April 7, 8, and 9, 1902, for the purpose of examining and testing the latest model Mauser automatic pistol, caliber 7.63 mm., or 0''.3008.

Present all the members, also Mr. Paul Mauser, second, Oberndorf, Germany, and Mr. Justus von Lengerke, of Messrs. Von Lengerke & Detmold, New York, representatives of the manufacturer.

The board then examined four Mauser automatic pistols, two officers' model, with barrel 3''.9 long and small grip, one containing 6 cartridges in the magazine and the other 10; and two of enlisted men's model, with barrel 5½ inches long, one having 6 cartridges in the magazine and the other 10. One of these pistols had a safety cocking device, easily operated by the thumb of the right hand. When the hammer was down, it interposed between the hammer and the firing pin, making it safe. Pulling back this safety device with the thumb cocked the hammer, the device detaching itself from the hammer and leaving the pistol free to fire.

During the test the pistol was fired by Mr. R. T. Hare, expert marksman at this armory, except when otherwise indicated.

For the test, the pistol (No. 34307) intended for the enlisted men's use, with large grip, 5½-inch barrel, 10 cartridges in the magazine, and sighted to 1,000 meters, was selected. The pistol is carried in a black-walnut holster or case, which also serves as an extension stock or pistol carbine.

The weights and other principal characteristics of this pistol are as follows:

Caliber, 7.63 mm., equivalent to 0''.3008; weight of pistol, 2 pounds 8 ounces; weight of stock, 15.7 ounces; weight of pistol, complete with stock, 3 pounds 7.7 ounces; number of components (not including case or stock), 36, including 4 flat springs, 4 spiral springs, and 1 screw; no pins.

	Grains.
Weight of bullet	84¾
Weight of powder charge (Rottweil)	7¾
Weight of complete cartridge	151.7
Weight of clip and 10 cartridges	1,805
Weight of clip	288

Five boxes of 20 cartridges each, with clips, 2 pounds 12 ounces.
Length of barrel, 5½ inches.
Velocity at 50 feet from the muzzle, 1,413 feet per second.

These pistols are like the Mauser pistol described in Appendix 15, report of the Chief of Ordnance, 1900, except in the following particulars:

1. The trigger seat is made solid with frame.
2. The trigger pin is solid with trigger.
3. The sear spring is made stronger.
4. The plate closing end of breechblock has been abandoned. At the rear end of the breechblock is a circular hole, with two elongations. This admits the firing pin, which has lugs corresponding to these elongations. A slot in the end of the firing pin permits a half turn by a screw-driver when the lugs are beyond the inner face of

the hole. This last point greatly facilitates the dismounting of the pistol. Dismounting is effected without the use of a special tool.

5. The arc through which the safety-lock thumb piece works has been greatly enlarged, showing at a glance whether the hammer is locked or not and making it much easier to operate the safety lock.

6. A good feature of this model in the safety lock is that when the pistol is carried with a cartridge in the chamber the hammer can be let down and the safety lock pushed upward and forward into the locking position, with the effect not only of locking the hammer but of automatically slightly withdrawing its face from the head of the firing pin. This form of safety lock greatly diminishes the difficulty of operating the pistol with one hand.

7. The front mainspring spindle of the model previously tested is replaced by one with greatly enlarged head which is slotted for the rocker, one of whose arms engages with a hook projection on the under side of the bolt lock. A rib on the under side of the slotted spindle head near its rear extends nearly to the sear when bolt is locked. When the bolt is unlocked, this rib, moving farther to the rear, comes in contact with the sear and pushes its nose to the rear beyond the reach of the trigger. The pulling of the latter can not then affect the sear and the piece can not be discharged until the bolt is locked, nor can missfires occur by reason of the firing pin not being in contact with the head of the cartridge.

The pistol after examination by the board was submitted to the following tests:

First. Time to dismount pistol, 1 minute 4½ seconds. To assemble, 2 minutes and 53⅘ seconds. Tools employed, 2—a screw-driver and a combination wiping rod and screw-driver.

Second. Twenty shots fired into butt to observe working of pistol. Action, easy and regular. Shots could be fired singly or in rapid succession, as desired. Easy to load.

Third. Velocity at 50 feet from muzzle. Mean of 5 rounds, 1,413 feet.

Fourth. Accuracy and penetration at 75 feet. Mean absolute deviation, 5 shots, 0″.91. Average penetration in white pine (5 shots), 10½ inches.

Fifth. Rapidity with accuracy; target 6 feet by 2 feet; range 100 feet.

(*a*) Thirty rounds; pistol fired from the shoulder as a carbine in 53⅗ seconds; 29 hits.

(*b*) Thirty rounds fired from the hand; 1 minute and 3 seconds; 12 hits. On the fourth shot, one cartridge jammed.

Mr. Mauser was then allowed to fire the pistol, with the following results:

Thirty shots as carbine—time, 41½ seconds; hits, 30. Thirty shots as pistol—time, 42½ seconds; hits, 18.

Sixth. Endurance test. The pistol was fired 500 rounds, being cooled after each 50 rounds.

First 50.—At 22d shot the barrel did not go forward; hammer did not cock; shell not ejected. 23d shot, jam due to shell not being fully extracted. 41st and 42d shots, empty shell not ejected.

The pistol was then oiled slightly, as it had been already fired considerably without cleaning.

Second 50.—At 52d shot, barrel did not go into position to the front, hence the pistol could not be fired.

Third 50.—At 131st shot there was a failure to eject empty cartridge shell. 132d shot, same.

Pistol oiled slightly. 141st shot, barrel did not go fully forward; cartridge case not ejected. 144th shot, same. 145th shot, bolt did not feed cartridge, but had to be pushed in by hand.

Fourth 50.—At 174th shot, shell extracted but not ejected, causing jamming.

Fifth 50.—At 201st shot, bolt did not feed cartridge; had to be pushed forward by hand. 226th shot, shell extracted but not ejected, being held between the head of the bolt and rear of the barrel. 239th shot, same.

Sixth 50.—At 276th shot, empty shell not extracted.

Seventh 50.—At 313th shot, bolt pushed over head of cartridge in magazine; cartridge shell pushed into the chamber and jammed; relieved by hand. 321st shot missfired but fired upon second trial.

Eighth 50.—At 351st shot, barrel did not go completely forward, but was pushed forward by hand. 372d shot, empty shell jammed between the head of bolt and end

of barrel. 385th shot, the same, with cartridge jammed in addition. 392d shot, jam due to empty shell not being ejected.

Ninth 50.—At 411th shot, barrel did not go forward completely; pushed forward by hand. At 412th and 413th shots, empty shell not extracted. 421st shot, missfired; fired upon second trial. 430th shot, failed to extract empty shell.

Tenth 50.—462d shot, empty shell jammed between head of bolt and rear of barrel.

Mr. Mauser stated that the manner of putting in the cartridges, especially pushing down the last cartridge well into the magazine, had something to do with the jamming. He was then allowed to fire 150 rounds, which was done without miss or jam, except that at the 52d round the cartridge did not feed properly into the chamber.

The board noticed that the cartridges were not crimped, but the cartridge case was attached to the bullet by three "stabs," and that there was a sharp corner in the receiver against which the forward end of the brass case of the cartridge caught or jammed in loading. Mr. Mauser was permitted to round this corner, after which he fired 100 shots without any hitches.

Seventh. Velocity at 50 feet. Mean of three rounds, 1,399 feet per second.

Eighth. Rapidity at will. Mr. Mauser fired 50 cartridges in 53⅘ seconds. The second cartridge did not feed properly.

Ninth. Dust test. The pistol was exposed, with mechanism closed and both ends of the barrel tightly corked, in a box prepared for that purpose, to a blast of fine sand dust for 15 seconds. Surplus sand was removed by blowing thereon and wiping with the bare hand. The pistol was then fired 10 shots into a sand butt in 3 minutes and 43 seconds. The first four shots were not extracted automatically. Last shot, breech did not open and had to be opened by hand. After these 10 shots the mechanism worked properly but stiffly. Upon examination, the board found fine dust on the block, but lock case was quite free from dust.

Tenth. Rust test. The mechanism was thoroughly cleansed of grease, the ends of the barrel tightly corked, and the pistol placed in a solution of sal ammoniac for five minutes. It was then exposed to the open air for 24 hours and fired 10 shots into a sand butt.

The pistol worked hard and closed stiffly at first.

Ten shots were fired in 1 minute and 10 seconds, the barrel not returning to the firing position after each discharge for several shots; then the block was worked back and forth several times with difficulty. The bearing surfaces were then oiled without taking the pistol to pieces, and 10 shots fired again, when it worked better. Upon taking the pistol to pieces, the firing-pin spring was found broken in four pieces. Oil was poured in slide and broken firing-pin spring replaced.

Ten shots were then fired, the pistol working stiffly. All the parts were then oiled but not cleaned, and 10 shots fired, when pistol worked properly.

Eleventh. Supplemental endurance test. The pistol was then fired 500 rounds without hitch of any kind by Messrs. Hare, Bull, Mauser, and the recorder of the board.

The board is of the opinion that this pistol has successfully passed the programme of tests for automatic pistols.

The board recommends that a number of these pistols be purchased and issued for actual trial in the field, to determine the suitability of the system for the service. The reports of the officers to whom these pistols are issued for trial should cover the following points:

1. The advantages and disadvantages of automatic pistols as compared with the revolver.
2. The advantages and disadvantages of this particular arm as compared with the revolver.
3. The advantages and disadvantages of this pistol as compared with such other automatic pistols as the officer may be familiar with.
4. The suitability of automatic pistols for the use of enlisted men.
5. If not deemed suitable for use by the enlisted men as a whole, would it be advisable to issue them for the use of officers and noncommissioned officers?
6. Should the caliber adopted by the service be larger than that of the pistol tested—0″.3008?

There being no further business before it, the board adjourned to meet at the call of the president.

JOHN E. GREER,
Major, Ordnance Department, U. S. Army, President.
J. PITMAN,
Major, Ordnance Department, U. S. Army.
JNO. T. THOMPSON,
Captain, Ordnance Department, U. S. Army, Recorder.

SPRINGFIELD ARMORY, MASS.,
April 26, 1902.

The foregoing proceedings and recommendations of the board are approved.

If these pistols are subjected to a test in the field, attention is invited to the fact that the Colt automatic pistol, the caliber of which the Department requires to be 0".38, is at a distinct disadvantage when compared with any automatic pistol of a caliber of 0".30, and the sixth point upon which reports of officers are invited is, therefore, very pertinent.

FRANK H. PHIPPS,
Lieutenant-Colonel, Ordnance Department, U. S. Army, Commanding.

(13092—320 Enc. 2.)

[Third indorsement.]

OFFICE OF THE CHIEF OF ORDNANCE,
Washington, April 30, 1902.

Respectfully submitted to the honorable the Secretary of War, recommending that the inclosed report of trials of improved Mauser automatic pistol be referred to the Board of Ordnance and Fortification. The recommendations contained in the within report are approved by this Department. * * *

WILLIAM CROZIER,
Brigadier-General, Chief of Ordnance.

[Fourth indorsement.]

WAR DEPARTMENT, *May 1, 1902.*

Respectfully referred to the Board of Ordnance and Fortification.
By order of the Secretary of War:

JOHN C. SCOFIELD, *Chief Clerk.*

[Fifth indorsement.]

BOARD OF ORDNANCE AND FORTIFICATION,
Washington, D. C., July 11, 1902.

Respectfully returned to the Chief of Ordnance; the Board, at its meeting of June 25, 1902, having recommended that no further tests be had at this time with the Mauser pistol.
For the board:

G. H. POWELL,
Secretary Board of Ordnance and Fortification.

TWELFTH REPORT OF THE BOARD OF ORDNANCE AND FORTIFICATION.

REPORT OF THE BOARD OF ORDNANCE AND FORTIFICATION.

War Department,
Washington, D. C., October 1, 1902.

The Secretary of War.

Sir: Under the provisions of the act approved February 24, 1891, the Board of Ordnance and Fortification has the honor to submit, for transmission to Congress, its twelfth annual report, covering the fiscal year from July 1, 1901, to June 30, 1902.

CHANGES IN PERSONNEL.

There have been several changes in the personnel of the board since the date of the last report. Gen. A. R. Buffington, Chief of Ordnance, having reached the statutory limitation of age, was retired from active service November 22, 1901, and his successor in office, Gen. William Crozier, was detailed as a member of the board by virtue of paragraph 25, Special Orders, No. 279, Headquarters of the Army, Adjutant-General's Office, December 3, 1901. Col. J. P. Story, Artillery Corps, was relieved from duty with the board by paragraph 6, Special Orders, No. 47, Headquarters of the Army, Adjutant-General's Office, February 25, 1902, and was succeeded by Maj. Sedgwick Pratt, Artillery Corps, detailed by paragraph 17, Special Orders, No. 78, Headquarters of the Army, Adjutant-General's Office, April 2, 1902. General Crozier was relieved and Maj. Charles Shaler, Ordnance Department, detailed as a member by paragraph 13, Special Orders, No. 91, Headquarters of the Army, Adjutant-General's Office, April 17, 1902, and by paragraph 14 of the same order Capt. Harry Taylor, Corps of Engineers, succeeded Capt. I. N. Lewis, Artillery Corps, as recorder.

The board as now organized consists of the following members: Lieut. Gen. Nelson A. Miles, commanding the Army, president; Brig. Gen. George L. Gillespie, Chief of Engineers; Col. John I. Rodgers, Artillery Corps; Col. Wallace F. Randolph, Chief of Artillery; Maj. Charles Shaler, Ordnance Department; Maj. Sedgwick Pratt, Artillery Corps, and Hon. Thomas J. Henderson, civilian member.

LEGISLATION.

The only legislation affecting the board is contained in the fortifications appropriations act approved June 6, 1902, making appropriation for continuing the work of the board, as follows:

To enable the board to make all needful and proper purchases, experiments, and tests to ascertain, with a view to their utilization by the Government, the most effective guns, small arms, cartridges, projectiles, fuses, explosives, torpedoes, armor

plates, and other implements and engines of war, and to purchase or cause to be manufactured, under authority of the Secretary of War, such guns, carriages, armor plates, and other war material as may, in the judgment of the board, be necessary in the proper discharge of the duty devolved upon it by the act approved September twenty-second, eighteen hundred and eighty-eight; to pay the salary of the civilian member of the Board of Ordnance and Fortification provided by the act of February twenty-fourth, eighteen hundred and ninety-one, and for the necessary traveling expenses of said member when traveling on duty as contemplated in said act; for the payment of the necessary expenses of the board, including a per diem allowance to each officer detailed to serve thereon, when employed on duty away from his permanent station, of two dollars and fifty cents a day; and for the test of experimental guns, carriages, and other devices procured in accordance with the recommendation of the Board of Ordnance and Fortification, one hundred thousand dollars, the expenditure of which shall be made by the several bureaus of the War Department heretofore having jurisdiction of the same, or by the board itself, as the Secretary of War may direct: *Provided*, That before any money shall be expended in the construction or test of any gun, gun carriage, ammunition, or implements under the supervision of the said board, the board shall be satisfied, after due inquiry, that the Government of the United States has a lawful right to use the inventions involved in the construction of such gun, gun carriage, ammunition, or implements, or that the construction or test is made at the request of a person either having such lawful right or authorized to convey the same to the Government.

That all material purchased under the foregoing provisions of this act shall be of American manufacture, except in cases when, in the judgment of the Secretary of War, it is to the manifest interest of the United States to make purchases in limited quantities abroad, which material shall be admitted free of duty.

FINANCIAL STATEMENT.

In compliance with the act of February 24, 1891, which requires "a detailed statement of all contracts, allotments, and expenditures made by the board," an exhibit, marked Appendix A, accompanies this report, giving a detailed statement of the allotments and expenditures from July 1, 1901, to June 30, 1902, the period covered by this report.

It will be noted that the act mentioned requires a detailed statement of "all contracts," etc. Prior to 1901 the board made no contracts directly, all such agreements being made by the bureaus of the War Department having jurisdiction of the subject-matter of such contracts. By the act of March 1, 1901, the board was given authority, subject to the approval of the Secretary of War, to disburse its own funds for experimental purposes, and consequently to enter into contracts without the intermediary of any bureau of the War Department. The board has, however, exercised this authority in one instance only. This was in case of contract with the Bethlehem Steel Company, dated November 26, 1901, for furnishing dummy guns and mounts to which were attached face-hardened steel shields. The amount of this contract was $8,301, and it was duly fulfilled.

July 1, 1901, the board had on hand $209,662.53, and by the act of June 6, 1902, the further sum of $100,000 was appropriated; to this must be added the sum of $11,449.48 revoked from prior allotments, making the total available, $321,112.01. Allotments have been made amounting to $106,396.53, leaving a balance June 30, 1902, of $214,715.48 for continuing the work of the board.

SUBJECTS CONSIDERED.

In the accompanying Appendix B will be found a complete list of the subjects considered by the board, together with a brief statement of the action taken in each case. From this list it will be seen that the

subjects considered vary widely in character, while the devices presented are designed for many different purposes. Where the invention has been considered worthy of development, allotment has been made either for purchase or to assist the designer in perfecting the invention. It is believed that no device presented to the board and promising usefulness in the military service has been neglected, and the party presenting such has in every case been given encouragement. Such, at least, has been the earnest purpose of the board.

GENERAL OPERATIONS.

The operations of the board during the fiscal year just closed have been directed toward the solution of several important problems. As forecast in the last annual report, the test of mortars which was conducted in Portland Harbor, Maine, has been completed and the results have, in the opinion of the board, fully justified the expense involved in this the first practical test on an extensive scale of the 12-inch mortar which forms so great a part of our coast armament. A most satisfactory report of the test was rendered by the local board of officers which conducted the firing, and this, combined with the comments and recommendations of this board, has been prepared for confidential issue to the officers of artillery. That the test has excited a great deal of interest has been shown by the number of requests received for copies of the report, but owing to the nature of the report it has been necessary to refuse such requests.

The firing at shields and dummy guns on mounts capable of being traversed, which was conducted on the proving ground of the Bethlehem Steel Company, is believed to be the first time that such a test has been conducted. The results confirmed the board in its previous recommendation that all coast defense guns on nondisappearing barbette mounts should be provided with protective shields. Further experiments in this line have been provided for and are under way.

An exhaustive test of field artillery material has been conducted extending over a period of eight months. While the test has been completed, the board has not yet made any definite recommendations as to the adoption of a type rapid-fire field gun.

It having been found impracticable to carry out the experiments in fire control and direction originally intended to take place at Fort Wadsworth, N. Y., the work has been transferred to Pensacola Harbor, Florida, and satisfactory progress has been made in the experimental installation at that place. The test will be conducted this fall.

THE HUNDRED-GUN CONTRACT.

By the terms of the contract entered into November 7, 1891, between the Bethlehem Iron Company, now the Bethlehem Steel Company, and the Chief of Ordnance, the company agreed to deliver twenty-five 8-inch, fifty 10-inch, and twenty-five 12-inch guns for coast defense.

The present condition of the work is as follows:

Eight-inch guns, all delivered.

Ten-inch guns, all delivered except 5, which are in various stages nearing completion.

Twelve-inch guns. 13 delivered, remaining 12 well under way, 2 being practically completed.

EXPERIMENTAL GUNS AND CARRIAGES.

The 10-inch Brown segmental-tube wire-wound gun.—This gun was built under an allotment of $33,000 made by the board September 15, 1896. On December 22, 1899, the completed gun was inspected by the board at the shops of the Reading Iron Company, Reading, Pa., and on January 9, 1900, it was shipped to the proving ground at Sandy Hook.

Owing to delays on the part of the trustees of the Brown patents in designating a suitable powder, the preliminary firing tests of the gun were not begun until February, 1901. The first proof round, with a pressure of 10,000 pounds, developed a crack extending through the third chase hoop. As this hoop is simply a thin covering used to protect the wire from mechanical injury, it was not believed that the defect had in any way weakened the gun, and on March 6, in the presence of the board, three additional rounds were fired with pressures ranging from 15,700 pounds to 26,900 pounds. It being evident from these and subsequent rounds that with the special kind of powder determined upon by the trustees the required velocities could not be obtained, the Board on April 6, 1901, granted the request of the trustees to increase the chamber capacity of the gun. This alteration necessitated sending the gun to the shops of the manufacturers. When returned it was again mounted, and firing tests renewed on October 28, 1901.

On the second round, with a charge of 175 pounds Du Pont smokeless powder for 12-inch rifle, and a recorded pressure of 51,550 pounds per square inch, the breech bushing, which was of cast steel and carried the breechblock and mechanism, was torn from the gun for a distance of about 10 inches and blown backward several hundred feet, overturning two or three mortars which were lying on skids and causing some other minor damage, but fortunately no loss of life. On October 31, 1901, the board inspected the gun and found that, except as above indicated, it was uninjured. Permission was granted the trustees to remove the gun for repairs, with the understanding that the Government was to be put to no expense therefor. The gun has not yet been returned for continuance of tests.

The Bofors cast-steel 15-cm. gun.—On January 19, 1898, the board made an allotment of $13,000 to procure from the Aktiebolaget Bofors-Gullspang, of Sweden, one 15-cm. rapid-fire cast-steel gun of the latest pattern, with pedestal mount and 100 rounds of ammunition. An additional allotment of $2,417 for the same purpose was made April 12, 1898. Although it was the understanding at the time of making the allotments that the material would be delivered ready for test within twelve months, the gun and projectiles were not received at the proving ground until July of 1901, and owing to lack of space was not mounted until March, 1902, when preliminary firing was commenced to determine the proper charge of powder to be employed, the company not being able to ship the necessary powder, for which an allowance in contract price was made. On April 5, 1902, an allotment of $1,673 was made for ammunition for test of this gun. Since March the test has been continued as time and the various other necessities of the proving ground have permitted.

The Vickers-Maxim 6-inch gun and mount.—On the recommendation of the Chief of Ordnance, the board, on January 26, 1900, made an

allotment of $18,500 for the purchase and delivery of a type 6-inch rapid-fire gun with pedestal mount, the equipment to be of the very latest and most improved pattern manufactured by Vickers, Sons & Maxim. On October 4, 1900, an allotment of $2,000 was made for procuring smokeless powder charges for use during tests of the gun, and on April 5, 1902, a further allotment of $4,794 was made to provide the additional ammunition necessary for test of the gun under the program approved by the board. The test of the gun was commenced in February of the present year and has continued since as time and the pressure of other work would permit.

The 10-inch Howell disappearing carriage.—This carriage was constructed under a special act of Congress, approved June 6, 1896, appropriating $50,000 for the purpose, and it has been tested, accepted, and paid for. On April 25, 1899, the board recommended the adoption of this carriage as an additional type for the service. The Secretary of War, in withholding his approval of the recommendation, referred the matter to the board for further consideration and report. At its meeting July 12, 1899, the following action was taken:

The board, having fully and carefully considered the subject, desires to state that in taking its action of April 25, 1899, recommending the adoption of the Howell disappearing gun carriage as an additional type carriage, it was not the intention of the board to supplant the present service carriage. It was and is the opinion of the board that the Howell carriage possesses certain mechanical and economical advantages, and may be used in such numbers and at such places as may be determined by the best interests of the Government. The board therefore adheres to its original recommendation, that the Howell disappearing gun carriage be adopted as an additional type service carriage for use in our coast defenses.

The Secretary of War desiring further and more complete firing tests, the board, at the request of the licensee of the Howell patents, made an allotment of $5,605.10 to cover the cost of certain changes in the traversing and retraction mechanism and in the mounting. These changes were completed, and on June 25, 1901, the carriage was subjected to a further firing test before the artillery committee of the board. The report of the committee, which was approved, states that "the traversing and retraction mechanism are crude and unsatisfactory and much inferior to those found in the present service carriages, but it is also the opinion of the committee that neither of these features is an essential part of the Howell disappearing system."

During the past year the carriage has been dismantled and removed to make room for the engineering work on fortifications in progress on the site of the old proving battery.

Emery 12-inch elevating carriage.—The construction of this carriage was authorized by a special act of Congress appropriating $130,000 for the purpose in February, 1893, and the work is still in progress. Additional appropriations of $10,000, June 6, 1896, and $40,000, May 25, 1900, have since been added to the original amount, making a total of $180,000 provided by Congress for the completion of the carriage, the necessary loading apparatus, and ammunition for test. Of the amount appropriated, the sum of $133,146.41 has been paid, of which some $12,500 is for ammunition to be used in the test of the carriage when completed. The progress made during the past year is best shown by the following extract from letter of Mr. A. H. Emery, the designer and contractor, dated August 2, 1902:

Since my report of September 30, 1901, there have been finished 2,827 pieces of work for this carriage and the loading apparatus, not including 1,300 rivets. All

value of shields for coast-defense guns, and confirms the opinion of the board as expressed in its action of June 5, 1901."

A question having arisen as to whether or not the impact of projectiles upon a shield rigidly attached to the sleeve of a gun will prevent free recoil of the gun in the sleeve, and in order also to determine the resisting power of somewhat thicker shields than those tested, the board on March 5, 1902, made an allotment of $7,600 for the construction of a similar shield of face-hardened steel 4½ inches thick, to be rigidly attached to the gun sleeve and to be mounted on the 6-inch experimental gun now in course of construction by the Bethlehem Steel Company for the board. This work is well advanced and when completed the shield will be subjected to firing tests to determine the points at issue.

The shield designed by the Bethlehem Steel Company consists of two wings or sides slightly bent and joined at the front end, inclosing a triangular-shaped space with the muzzle of the gun projecting from the apex. The Ordnance Department believing that a curved shield will offer greater resisting properties has designed such a shield, and on June 25, 1902, the board made an allotment of $10,640 for the construction of one of these shields 4½ inches thick and face-hardened. This shield is also to be fitted to the 6-inch experimental gun mentioned and will enable the board to conduct comparative firing tests to determine the resisting qualities of each form of shield.

RAPID-FIRE GUNS AND MOUNTS.

Bethlehem 5-inch gun on combination carriage.—On May 4, 1900, the board made an allotment of $14,000 for the construction of a 5-inch gun and carriage proposed by the Bethlehem Steel Company. The carriage is of a special type intended to combine the characteristic features of both the disappearing and rapid-fire mounts. It is understood, and is stipulated in the contract, that before payment is made for the material it must pass such firing tests as may be prescribed by this board. The contract was dated July 2, 1900, and gun and carriage were to have been delivered ready for test not later than July 2, 1901. Owing to the experimental nature of this carriage, the work has been somewhat delayed, but gun and mount are now about 95 per cent completed.

Bethlehem 6-inch rapid-fire gun and mount.—On January 3, 1901, the board made an allotment of $17,900 for the construction of a type 6-inch rapid-fire gun with pedestal mount as designed by the Bethlehem Steel Company.

This gun is to give a muzzle velocity of at least 3,000 foot-seconds with a projectile weighing 100 pounds and without excessive pressures, the rate of fire to be at least eight rounds a minute. The ammunition for the proof-firing test will be furnished by the company without expense to the Government, and the equipment is not to be paid for unless it fulfills the specified requirements.

Under date of July 30, the company report the gun assembled with the exception of one hoop, which was condemned after having been finished bored ready for assembling on the gun. The replacing hoop has been tested and accepted and will immediately be finished bored and put on the gun. The pedestal and top carriage for this mount, as well as the shafting, are completed, and the shields are well under way,

as are the minor parts. As this mount is now to be used in the experimental test of 4½-inch shields, certain modifications in design have been necessitated, and this has caused some delay in completion of the work.

TEST OF MORTAR BATTERIES.

On the recommendation of Col. J. P. Story, inspector of artillery, Department of the East, and subsequently detailed as a member of the board, at its meeting March 8, 1901, the board made an allotment of $20,000 for the purpose of making a thorough service test of the mortar batteries which at present form an important part of our coast armament. The harbor of Portland, Me., was selected as the one most suitable for the test, the mortar batteries there being so located as to permit of practice firing at both land and water targets under conditions closely approximating those of actual service.

The tests were conducted by a local board of officers consisting of Col. J. R. Myrick, Capt. F. S. Harlow, and Capt. C. J. Bailey, all of the Artillery Corps. This board was assisted by the following officers of the Artillery Corps during the tests: Capt. G. W. Gatchell, Capt. F. E. Harris, Capt. A. W. Chase, Capt. Brooke Payne, Capt. S. C. Vestal, Lieut. H. J. Hatch, Lieut. A. B. Putnam, and Lieut. A. E. Waldron. In closing its report the local board expressed its appreciation to these officers "for the efficient manner in which they have performed their duties as observers, computers, predictors, plotters, etc., and for the enthusiasm and interest shown by them in their work."

The Board of Ordnance and Fortification desires also to put on record the remark incorporated in the report of its artillery committee in regard to the conduct of the tests, as follows:

> An attentive study of the report of the board of artillery officers charged with the recent test of mortar fire in Portland Harbor, Maine, shows that they—Colonel Myrick, Captain Harlow, and Captain Bailey—conducted their work with great zeal, industry, and professional skill, and they deserve congratulations on its very successful completion.

The tests were commenced in October and continued through November, as local conditions permitted. A detailed record was kept of each shot fired, and this has been incorporated in the report of the tests which has been prepared and distributed for the confidential use of officers of artillery. The data thus obtained will, in consequence, be constantly available in the hands of those to whom it will be of the greatest benefit. If for no other reason, this fact alone would justify the outlay necessary.

FIELD GUNS AND CARRIAGES.

Competitive test of rapid-fire field guns.—The board, at its meeting October 5, 1900, prepared a program covering a comprehensive series of competitive tests of rapid-fire field guns and carriages, the purpose of which was to obtain for our service the most improved and efficient rapid-fire equipment of this kind possible. This program was sent to all the prominent manufacturers of ordnance material in this country and abroad, of whom a number expressed an intention of submitting equipments, but several of these subsequently withdrew.

The following is a list of the equipments finally presented and entered in the competition:

1. Cockerill-Nordenfelt.
2. Armstrong-Whitworth.
3. Vickers-Maxim.
4. Ehrhardt.
5. Bethlehem Steel Company.
6. Ordnance Department short recoil.
7. Ordnance Department long recoil.
8. Design of Capt. I. N. Lewis, Artillery Corps.

The program first adopted was subsequently modified in some minor details, the principal change being in the provision that a certain portion of the tests should take place at Fort Riley, Kans.

The following is the program as finally prepared by the Board:

PROGRAM OF TESTS FOR FIELD ARTILLERY.

WAR DEPARTMENT,
BOARD OF ORDNANCE AND FORTIFICATION,
Washington, D. C., October 22, 1901.

The following is the program for the tests of field artillery material to be conducted under the direction of the Board of Ordnance and Fortification.

The tests printed in *italics* are to be conducted at Fort Riley, Kans.

REQUIREMENTS.

1. Total weight allowed behind horses, approximately 3,950 pounds.
2. Weight of common shell loaded and fuzed, 15 pounds.
3. Muzzle velocity, 1700–1750 f. s., with a pressure not to exceed 33,000 pounds per square inch.

Manufacturers submitting material for test will furnish gun, carriage, limber, and all tools and equipments complete for assembling, dismounting, care, and service of the piece.

The ammunition required during the tests will be furnished at the expense of the Government.

The powder, in addition to giving the required velocity, shall be of a known and satisfactory composition.

Two cases of ammunition, packed and sealed for shipment, will be furnished.

All projectiles will be delivered filled with sand to the required weight and fuzed with a blank fuze plug.

During the tests the repair of such minor defects as may occur, and which can be made without material delay, will be permitted. Changes in construction will not be permitted.

Any defect which shows violation of an essential principle of construction will discontinue the tests of the material unless in the opinion of the Board further tests are warranted.

INSPECTION.

1. A careful inspection to be made of the gun. In the breech mechanism the number of parts, their simplicity, strength, and certainty of action to be noted. The ease with which the mechanism can be assembled and dismounted, together with tools necessary for this operation. Special notice to be made of those mechanisms permitting dismounting after any part jams while breech is closed, and special note will be made of those mechanisms permitting a firing of the gun or primer before the breech is closed and locked.

During this inspection ten or more rounds may be fired.

2. A similar inspection of the carriage. In this, special note will be made of the following:

(*a*) Weight and construction of wheels.
(*b*) Space between naves.
(*c*) Free space under carriage when limbered.
(*d*) Simplicity and certainty of elevating and traversing gear.
(*e*) Amount of lost motion in these gears.

(*f*) Accuracy of elevating device, including the sight radius or its equivalent.

(*g*) The nature of the devices for limiting the recoil, and, if hydraulic, the kind of fluid to be used in the cylinders and the ease with which the cylinders can be filled.

(*h*) Operation of firing, and road brakes, if any.

(*i*) Ease with which broken parts can be replaced, etc.

(*j*) Ease with which gun can be mounted.

(*k*) Speed with which gun can be elevated and depressed and moved from one extreme to the other in azimuth, and these with wheels level and with one wheel higher than other. Power required on handwheels or cranks to be noted.

(*l*) Location of sights for easy and quick laying, especially while loading.

(*m*) The number of bearing surfaces, the facility for cleaning them, and the means provided for proper lubrication.

(*n*) Length of trail and weight on trail in limbering.

(*o*) An examination of the calculations on which the strength of various parts were determined. For this purpose the calculations should be submitted with the description of the carriage. It is desirable that one rotation of the elevating wheel or crank should correspond to an even reading in elevation.

FIRING TESTS—SPECIAL.

VELOCITY.

Velocities and pressures will be taken at once to determine whether or not ballistic requirements are fulfilled, and at such times as may be necessary to insure the maintenance of these conditions.

ACCURACY.

Fifty shots, if necessary, to be fired at 2,500-yard target from clay or loam platform.

RAPIDITY.

Each gun and carriage will be subjected to four tests for rapidity.

1. Rapidly unaimed shots from loam platform, 10 rounds, the trail having been set by one shot.

2. Rapidity with accuracy from clay platform, 10 shell and 10 shrapnel at 2,500 yards, the trail having been seated and range secured by not exceeding two sighting shots.

3. Same from macadam road or rock platform.

4. Maintained rapidity: Forty-five aimed shots from clay platform. During this test the target will be twice changed, the targets being so placed that the trails will have to be shifted.

DEFECTIVE AMMUNITION.

Guns using metallic ammunition and those using any form of percussion primer to be subjected to a firing test of two rounds, with defective primers causing blowbacks, and ten rounds with cases weakened longitudinally by a cut extending nearly through the metal and within 2 inches of the head of the case.

DUST.

The mechanism of each gun and carriage to be exposed to a blast of fine dust in such manner as to insure its being uniformly and equally covered with dust. Ten rounds to be fired with elevations from 2° to 10° and from one extreme to the other in azimuth. Time to be noted.

RUST.

Mechanism of gun and carriage to be rusted thoroughly and uniformly as much as, and no more than, it would be under service conditions. Ten rounds as in preceding.

EXCESSIVE CHARGES.

Ten rounds to be fired with increasing pressures, as follows:

	Pounds.
Two rounds	35,000
Two rounds	38,000
Two rounds	40,000
Two rounds	42,000
Two rounds	44,000

GENERAL TESTS.

Five kinds of platform will be used for the test, i. e., clay, loam, sand, rock, and macadam.

On each there will be fired fifteen rounds at each of the three elevations, viz, extreme elevation, zero elevation, extreme depression, five rounds being with the gun in its extreme position, right; five rounds in mean position, and five extreme left.

In these tests the jump, departure from line of fire, and depth of trail and wheels will be noted. When necessary to move the trail, the power and time required will be noted.

In addition, twenty rounds will be fired with trail rigidly supported by an oak post set into the ground and braced to prevent yielding.

Carriages having recoil on the ground will, in rapidity tests, be limited to 40 feet, and the ground will be broken up to assimilate actual conditions.

SUPPLEMENTARY TESTS.

1. When metallic ammunition is used, ten rounds will be immersed in water for five minutes and then allowed to stand twenty-four hours before firing.

Ten additional rounds will be subjected to a humidity test at a temperature of 100° F. and relative humidity at 95° for thirty days and then fired.

2. Each limber with chest completely filled will be mounted on a vibrating table and be subjected to the jarring thereon for forty-eight hours.

A careful examination will then be made to see if the serviceability has been affected.

Same moisture test as in 1.

3. Limber chests filled will be exposed to the weather for two weeks and then examined and part of the contents fired.

4. Those guns and carriages which have not failed in the above will be subjected to a practice march of 150 miles, following country roads as much as possible.

Careful examination will be made of the equipment en route and at the end of the march.

Such additional rounds will be fired over and above those mentioned as may be deemed necessary to establish any point arising, and such additional tests will be conducted as may for any reason seem necessary to the Board of Ordnance and Fortification.

The competitive test of field artillery material was commenced before the board at Sandy Hook on October 17, 1901, and was continued at that place, and subsequently at Fort Riley, before the board or its representatives, up to the end of June. Comprehensive data were obtained, but no definite action had been taken by the board up to the end of the fiscal year.

MISCELLANEOUS MATERIAL.

AUTOMATIC GUNS.

McClean 1-pounder automatic gun.—In April and June, 1899, the board made allotments aggregating $884.28 to reimburse the Navy Department for a 1-pounder rifle barrel and 500 rounds of ammunition furnished S. N. McClean, who had submitted to the board a 1-pounder automatic gun and mount. On January 26, 1900, the board witnessed a preliminary firing test of the gun, and on May 4, 1900, made an allotment of $3,000 for the purchase of 1,000 rounds of ammunition, and to cover other incidental expenses of a thorough firing test of the equipment as soon as completed. In August, 1900, 500 rounds of ammunition was furnished Mr. McClean for use in the experimental development of his gun and the cost charged to the allotment of $3,000.

In the development of his automatic gun Mr. McClean had devised a recoil checking device, and on January 30, 1900, at his request, the board made an allotment of $1,000 to cover the construction and tests of a recoil checking device to be attached to the muzzle of one of the service 3.2-inch field guns which was furnished him for the purpose.

Mr. McClean, in a recent report to the board, states that during

the past year the company has been constantly engaged in perfecting for the military service their types of guns and in doing this have subjected them to exhaustive firing tests. Mr. McClean further says:

During the past month we have been doing target firing with one of these guns and find that the gun functions perfectly and that the recoil is so perfectly controlled that the gunner can sit on the bicycle seat on the trail and maintain or change the aim at will without annoyance from the kick of the gun and without changing the battery position of the arm. * * *

The target firing record of these guns and the exhaustive endurance tests which we have given them indicate that we have developed something which will be of value to the service. * * *

We have also made some important developments in connection with our recoil controlling devices for guns of larger caliber.

Hotchkiss automatic 1-pounder gun.—On June 8, 1900, the board made an allotment of $4,052.50 to purchase from the American Ordnance Company a Hotchkiss 1-pounder automatic gun and carriage, and on October 4, 1900, an additional allotment of $1,300 to procure the ammunition necessary for a test of the gun.

The gun was delivered at the proving ground in November, 1900, and on March 6, 1901, was fired in the presence of the board. It is now held awaiting competitive test with the Vickers-Maxim and McClean automatic guns.

Vickers-Maxim automatic 1-pounder gun.—April 4, 1900, the board made an allotment of $8,300 for the purchase of a Vickers-Maxim 1-pounder automatic gun and carriage and 2,000 rounds of ammunition. The equipment is now at the proving ground, and will be tested in competition with the Hotchkiss and McClean guns.

MISCELLANEOUS.

The Langley aërodrome.—Much interest has been aroused in the subject of aerial flight by recent experiments in air navigation and by the published statement of awards to be given by the Commissioners of the St. Louis Exposition.

The board has made allotments aggregating $50,000 for experiments to be conducted under the direction of Dr. S. P. Langley, Secretary of the Smithsonian Institution. This sum has been exhausted, and the work is now going on from a fund at the disposal of Dr. Langley. No more need be said at this time than that the progress of the work is satisfactory.

Horizontal base range finder.—On July 6, 1900, the board made an allotment of $200 to cover the cost of test of the principles involved in the design of a range finder proposed by Capt. H. C. Davis, Artillery Corps. Captain Davis reports, under date of July 19:

My regular work at the Artillery School has not permitted me to give any attention to this matter for some time. The apparatus was purchased for preliminary trial, but for reasons stated these have not been made. I expect to take up the matte. again when time permits.

Parkhurst clip.—An allotment of $1,739 was made by the board July 6, 1900, for the purpose of equipping 200 service rifles with the Parkhurst clip attachment and for the manufacture at Springfield Armory of 2,000 Parkhurst magazine clips. When completed these arms and clips were issued to troops serving in the field for test and report.

After careful consideration of the reports received from officers in the field it was the opinion of the board that the device has not sufficient value to warrant its adoption as a type for the service.

Ammunition cart and water carrier.—An allotment of $700 was made by the board November 9, 1901, for the construction by Mr. H. F. L. Allen of two ammunition carts and water carriers, the device being designed to work singly or in pairs. Mr. Allen reports the carts practically completed, and they will be tested during the coming fall.

Carriage for machine guns.—February 8, 1902, the board made an allotment of $1,000 for the construction of a sample carriage for machine guns, the design of Capt. John H. Parker, Twenty-eighth Infantry, who reports under date of July 22, 1902, that the work has progressed to the extent of obtaining two bidders on the construction and that their bids are now under consideration.

Phillips universal difference disk.—April 18, 1901, the board made an allotment of $50 to cover the cost of construction of a difference disk designed by Capt. C. L. Phillips, Artillery Corps. The device was constructed and tested at Fort Wadsworth, N. Y., and at Fort Monroe, Va. The Board has recommended that it be not adopted as a type for the service.

Cloke ballistic board.—On May 8, 1901, an allotment of $150 was made for the construction of two ballistic boards, the design of Capt. H. E. Cloke, Artillery Corps. After careful test at Fort Monroe this board has recommended that the device be not adopted.

Prentiss dial telegraph.—On April 13, 1898, the board made an allotment of $367 for the purchase of a dial telegraph, the design of the Prentiss Clock Improvement Company, of New York City, with the proviso that payment should not be made unless the instrument was deemed worthy of exhaustive test after preliminary trial. The allotment was subsequently, on December 4, 1900, increased by $200. When completed the instrument was installed at Fort Wadsworth and tested by a board of officers. As the result of the test this board recommended that the instrument be not adopted as a type for the service, but considered that it had sufficiently passed the prescribed tests to warrant payment to the company.

Rice shelter tent and blanket roll.—December 20, 1899, the board made an allotment of $600 for the purchase of a sufficient number of the Rice combined blanket roll and shelter tent to equip one battalion of infantry. These are now under test at Plattsburg Barracks, N. Y., but no report has been received as to their value.

Orndorff woven gun slings, etc.—May 8, 1901, the board made an allotment of $1,200 for the purchase of a number of Orndorff's woven gun slings, canteen and haversack straps. These were issued to a regiment of infantry stationed in the Philippines, but no report has been received.

Hoff's pouch for first-aid packet.—Col. J. Van R. Hoff, Medical Department, proposed a form of pouch designed to be attached to the cartridge belt for carrying the first-aid packet. On July 12, 1901, an allotment of $500 was made for the purchase of a number of these pouches. These have been issued to troops in the Philippines for trial, but no report has been received.

Service small arm, modification of Colonel Phipps.—The board made an allotment of $1,700 March 6, 1902, to provide for the manufacture of 100 rifles with modification suggested by Col. F. H. Phipps, Ordnance Department, the modification consisting essentially in shortening the barrel of the service rifle about 4 inches, with a corresponding

decrease in the weight of the arm. These rifles have been completed and issued to troops for trial, but no reports have been received.

Lanz canteen.—August 30, 1901, the board accepted the offer of the Lanz Manufacturing Company to furnish 100 of the Lanz canteens without expense to the United States for test. These canteens have been distributed to troops in the Philippines for trial, but no reports have been received.

Merriam pack.—April 5, 1900, Gen. H. C. Merriam, U. S. Army, appeared before the board and invited attention to the service value of the Merriam pack for carrying extra clothing, blanket, rations, etc.

The board recommended the purchase of 1,000 of these packs and their distribution to at least ten different regiments of infantry for trial and report. No reports of the results of these trials have reached this office.

Batson-Sawtelle road level.—November 17, 1896, the board made an allotment of $200 for the purchase of a road level, the design of Lieutenants Batson and Sawtelle, of the Army. Captain Sawtelle reports under date of August 25, 1902, that because of litigation relative to the patent the device was not further developed at that time, and the outbreak of the Spanish war has prevented the completion of the instrument, though the patent has now been secured.

Manning ammunition cart.—On January 3, 1901, the board made an allotment of $1,500 for the construction of an ammunition cart, the design of Maj. W. C. Manning. The cart was completed and exhibited to the board. It is now at Sandy Hook awaiting further competitive test.

Intrenching tools.—At its meeting December 19, 1899, the board took up consideration of the subject of intrenching tools, and after careful consideration of the recommendations and reports of many officers, giving the accumulated experience of our Army in the use of intrenching tools during the past thirty-five years, made the following comment:

> It is of the first importance to place in the hands of the troops not only the most destructive weapon but one that gives the greatest rapidity of fire. This requires a liberal supply of ammunition to be carried on the person of the soldier, and emphasizes the necessity of reducing the weight of his equipment to a minimum. The Board does not, therefore, feel justified in adding to the burden necessarily carried by the soldier, when rapidity of movement is of vital importance.
>
> With present methods and means of transportation, supplies and extra equipments may readily be furnished troops operating in the field, thus making available such implements as axes, picks, spades, and shovels for the heavier work of entrenching, road making, bridge building, etc.

To meet the demand for a tool suitable for use in constructing hasty cover for the individual soldier or for a line of troops exposed to the enemy's fire, without adding to the weight of the present equipment, the board recommended for experimental trial an instrument combining the qualities of bayonet, knife, and intrenching tool. This combination knife-bayonet was issued to troops serving in the field and was also exhaustively tested by a board of officers convened at the Engineer School of Application. As the result of these tests the board recommended that it be not adopted, and has now called upon the commanding officer of the Engineer School to submit samples of tools which, while ordinarily expected to be carried with the company equipage, may in emergency be transported by the individual soldier.

In connection with the foregoing the following table of the weights

transported by an infantry soldier, compiled from the latest available data, well illustrates the imperative necessity of reducing the required equipment at every possible point.

United States infantry soldier's equipment, heavy marching order.

Article.	Weight.		Article.	Weight.	
	Lbs.	*ozs.*		*Lbs.*	*ozs.*
Undershirt	1	2	Blanket bag—Continued.		
Drawers	1	0	Socks, extra		3¾
Socks		3¾	Towel		5
Blue shirt	1	4	Toilet articles		5
Trousers	2	0	Haversack and straps	1	9¼
Shoes	2	5	Meat can		15
Leggings		8⅜	Knife, fork, spoon		6
Blouse	2	4	Rations, three days	6	12
Hat, campaign		6	Canteen and strap	1	3¼
Woven belt	1	9¼	Tin cup		5
Cartridges, 200	13	8			
Rifle	10	1	*Résumé.*		
Bayonet	1	0			
Scabbard		11½	Clothing on person	11	1⅛
Blanket bag	2	4½	Rifle and equipments	26	13¾
Overcoat	7	0	Haversack and contents	9	10¼
Blanket	5	0	Canteen, tin cup, etc	1	8¼
Shelter tent	2	8¾	3 pints water	3	0
Poncho	2	12	Blanket bag and clothing	24	14
Shoes, extra	2	5			
Undershirt, extra	1	2	Total	76	15⅜
Drawers, extra	1	0			

AUTOMATIC PISTOLS.

Luger automatic pistol.—At its meeting April 6, 1901, the board made an allotment for $15,000 for the purchase from the Deutsche Waffen- und Munitions-Fabriken of Berlin of 1,000 Luger automatic pistols for practical service test by troops in the field.

The preliminary firing tests of this arm at Springfield Armory gave most satisfactory results. When received the pistols were distributed, five to each troop of cavalry in service, and the remainder to the light artillery and officers at West Point. Commanding officers of organizations receiving these pistols were instructed to make a report on the arm as the result of their tests, covering specifically the following points:

1. The advantages and disadvantages of automatic pistols as compared with the revolver.
2. Advantages and disadvantages of this particular arm as compared with the revolver.
3. Advantages and disadvantages of this pistol as compared with other automatic pistols.
4. Suitability of automatic pistols for the use of enlisted men.
5. If not deemed suitable for the use of the enlisted men as a whole, would it be advisable to issue them for the use of officers and noncommissioned officers?

A few reports have been received, but so far the number has not been great enough for the board to form an opinion of the service value of the arm. The tests are still in progress.

Colt's automatic pistol.—A new model of this arm having successfully passed the test at Springfield Armory, the board at its meeting January 11, 1902, made an allotment of $4,000 for the purchase of 200 of the latest model. These arms are to be distributed for practical field test, and report to cover the same questions as were asked in the case of the Luger pistol, above quoted.

COMPARATIVE TEST OF FIRE-CONTROL SYSTEMS.

On February 6, 1901, the board recommended that a comparative test be made at Fort Wadsworth, N. Y., of the relative merits of horizontal and vertical base position-finding systems and to determine the value of searchlights for coast defense, including a practical trial of the adopted system of fire control and direction. It was intended to ask the cooperation of the Navy in these tests.

The board had hoped to have these trials in the autumn of 1901, but in consequence of the unsettled condition of the artillery due to its reorganization it was impossible to detail enough officers to execute the program and the tests were deferred.

Early in January, 1902, it was determined, after a careful consideration of all the facts in the case, that the local conditions in Pensacola Harbor were more favorable for an exhaustive test of a system of fire control, and accordingly on January 6 the board made an allotment of $15,000 for the purpose of furnishing such experimental material as the regular supply departments are unable to furnish. This allotment was subsequently, on April 5, increased $5,000 for the same purpose.

Maj. G. N. Whistler, Artillery Corps, the officer in immediate charge of the installation, reports, under date of July 19, 1902, that "the work is well under way and it is hoped that it will be sufficiently advanced to begin the drill and instruction in its use preparatory to the test, during the month of August."

ESTIMATES FOR THE COMING YEAR.

In order to carry on the work of the board for the fiscal year ending June 30, 1904, an estimate of $200,000 has been submitted to the Secretary of War for transmission to Congress. This is the amount for which estimate was submitted last year, and, though not appropriated, the board feels again called upon to urge the necessity of granting the increase asked.

For several years past the allotments have exceeded the appropriations, and were it not for the fact that there is a small reserve fund the board would have been much handicapped.

On June 30, 1902, there was available for allotment $214,000. In the two months which have since elapsed, allotments aggregating $50,000 have been made, so that the available balance has been materially reduced.

It is felt, owing to the flexibility of its appropriation and the fact that it has in the past been instantly available for necessary experimentation, that the board is in position to carry on a valuable work, but this can only be continued with the assistance of a measure of liberality on the part of Congress.

The line of work carried on by the board is at times necessarily expensive, but it would be difficult to calculate the amount ultimately saved to the general appropriations by judicious experiment.

In the past, when the appropriations exceeded the necessities, the board itself recommended a decrease in the amount of its appropriation, and this would be its policy in the future.

The present and prospective demands on the funds of the board, it is submitted, necessitate the appropriation of $200,000, and it is recom-

mended that the appropriation be made as heretofore in a single amount to enable the board to make all needful and proper purchases, experiments, and tests to ascertain, with a view to their utilization by the Government, the most effective guns, small arms, cartridges, projectiles, fuses, explosives, torpedoes, armor plates, and other implements and engines of war, and to purchase or cause to be manufactured, under authority of the Secretary of War, such guns, carriages, armor plates, and other war material as may, in the judgment of the board, be necessary in the proper discharge of the duty devolved upon it by the act approved September 22, 1888; to pay the salary of the civilian member of the Board of Ordnance and Fortification provided by the act of February 24, 1891, for the necessary traveling expenses of said member, when traveling on duty as contemplated in said act; for the payment of the necessary expenses of the board, including a per diem allowance to each officer detailed to serve thereon, when employed on duty away from his permanent station, of $2.50 a day, and for the test of experimental guns, carriages, and other devices procured in accordance with the recommendation of the Board of Ordnance and Fortification, the expenditure of which shall be made by the bureaus of the War Department heretofore having jurisdiction of the same, or by the board itself, as the Secretary of War may direct: *Provided*, That before any money shall be expended in the construction or test of any gun, gun carriage, ammunition, or implements under the supervision of said board, the board shall be satisfied, after due inquiry, that the Government of the United States has a lawful right to use the inventions involved in the construction of such gun, carriage, ammunition, or implements, or that the construction or test is made at the request of a person either having such lawful right or authorized to convey the same to the Government.

RECOMMENDATIONS.

The board desires to again call attention to the recommendation contained in its last annual report and to urge the necessity of providing an adequate supply of ammunition and other material needed for service and for the thorough practical instruction of the men in charge of the guns.

These appropriations should be sufficient in amount to provide at least 100 rounds per gun of reserve ammunition for each large caliber gun and mortar as soon as mounted, and for the rapid fire guns provision should be made for a supply of reserve ammunition of at least 250 rounds per gun.

In addition to the above-enumerated supply of reserve ammunition, there should be provided an ample allowance of ammunition for the annual target practice. This allowance for each company of coast artillery should be not less than 21 rounds per year for practice with the 8-inch, 10-inch, or 12-inch rifles, or 12-inch rifled mortars, and not less than 24 rounds per company for the 4-inch, 4.7-inch, 5-inch, or 6-inch rapid fire guns, and not less than 30 rounds for the 6-pounder or 15-pounder rapid fire guns. The present allowance for subcaliber and machine gun practice should be continued.

It is also recommended that all target practice, except subcaliber, should be with full service charges of smokeless powder, as in no other way can the guns be satisfactorily operated or the personnel

adequately instructed in their manipulation. The present allowance of ammunition has not been sufficient to thoroughly test the guns after their installation.

The board renews the recommendation contained in its last two annual reports that steps be taken at an early date to provide the coast artillery personnel with suitable ranges and other facilities for carrying out each year a system of practical drill and target practice with heavy guns under conditions approximating those of actual service.

As the primary object of the defenses is to protect the harbors and waterways along our coasts, the guns are, as a rule, so placed that target firing, with full service charges and at longer and more important ranges, can seldom take place without endangering the lives and damaging the property of private citizens. This is particularly true in the case of fortifications defending the larger harbors, where there is shipping constantly within range, and where private houses are in such close proximity to the guns as to be seriously affected by shock. At least three such ranges should be provided—one for the North Atlantic, one for the South Atlantic and Gulf, and one for the Pacific coast.

(Signed) NELSON A. MILES,
Lieutenant-General Commanding the Army,
President of the Board.
G. L. GILLESPIE,
Brigadier-General, Chief of Engineers.
JNO. I. RODGERS,
Colonel, Artillery Corps.
WALLACE F. RANDOLPH,
Chief of Artillery.
CHARLES SHALER,
Major, Ordnance Department.
SEDGWICK PRATT,
Major, Artillery Corps.
THOS. J. HENDERSON,
Civilian Member of the Board.
HARRY TAYLOR,
Captain, Corps of Engineers, Recorder of the Board.

APPENDIX A.

Table Showing Allotments and Expenditures Made by the Board of Ordnance and Fortification from July 1, 1901, to June 30, 1902, Including Statement of Unexpended Balance.

Acts of 1892 to 1902, inclusive.

Balance on hand July 1, 1901		$209,662.53	
Act of June 6, 1902		100,000.00	
			$309,662.53
Revocations of allotments under these acts:			
1902.			
May 1.	From allotment of Dec. 5, 1901, for construction of a mechanical difference chart on design of Capt. H. E. Cloke	100.00	
June 25.	From allotment of Nov. 16, 1892, for tests, alterations, etc., of 12-inch mortar carriages	1,037.36	
	From allotment of Nov. 16, 1892, for tests, alterations, etc., of 8-inch barbette and disappearing carriages	361.04	
	From allotment of Nov. 16, 1892, for tests, alterations, etc., of 10-inch disappearing carriages	95.95	
	From allotment of Nov. 16, 1892, for repairs or alterations to 12-inch carriage for gun lift	1,564.00	
	From allotment of Nov. 16, 1892, for tests, alterations, etc., of 12-inch barbette carriage	734.00	
	From allotment of Nov. 16, 1892, for tests, alterations, etc., of 7-inch howitzer carriage	500.00	
	From allotment of Nov. 16, 1892, for tests, alterations, etc., of 7-inch mortar carriage	346.60	
	From allotment of July 13, 1897, for type 6-inch rapid-fire gun and disappearing carriage	733.51	
	From allotment of May 11, 1898, for electrical equipment of 10-inch gun at Fort Wadsworth	100.00	
	From allotment of Oct. 4, 1899, for two Pratt ballistic boards	15.88	
	From allotment of Oct. 17, 1899, for Batt's improved cartridge belt	10.50	
	From allotment of Dec. 20, 1899, for Rice combination blanket roll and shelter tent	.54	
	From allotment of March 1, 1900, for liquidation of expenses in connection with Squier-Crehore range finder	58.00	
	From allotment of Apr. 4, 1900, for Vickers-Maxim 37 mm. machine gun and carriage	81.58	
	From allotment of June 8, 1900, for combination knife, bayonet, and intrenching tool	2,900.17	
	From allotment of July 6, 1900, for Parkhurst clip attachment and clips	1,178.57	
	From allotment of July 6, 1900, for Davis horizontal base range and position finder	17.00	

Revocations of allotments under these acts—Continued.

1902.			
June 25.	From allotment of Aug. 2, 1900, for nonrosivec or metal bits	$1,180.00	
	From allotment of Aug. 23, 1900, for Vickers-Maxim field gun and carriage, with ammunition	362.00	
	From allotment of Oct. 4, 1900, for smokeless powder for Vickers-Maxim gun	7.45	
	From allotment of May 8, 1901, for woven gun slings, canteen and haversack straps	65.13	
	From allotment of July 12, 1901, for Hoff pouch to contain first-aid packet	.20	
			$11,449.48
			321,112.01

Allotments during the year:

1901.		
July 12.	Pouches for first-aid packet, design of Maj. J. Van R. Hoff, U. S. Army	500.00
Aug. 1.	Construction and test of bore sight according to design of Ordnance Department	200.00
6.	Auditor's settlement, for stationery and miscellaneous supplies for 1901	273.71
30.	Completion of equipment of type fire command at Fort Wadsworth	536.71
Oct. 2.	Platform for testing nondisappearing gun carriages	6,000.00
3.	Twelve experimental fuses, design of H. V. C. Keeson	120.00
17.	Ammunition for test of Lewis field gun	10,325.30
31.	Ammunition for test of Bethlehem Steel Company field gun	9,480.00
31.	Expenses of dismounting Howell and pneumatic disappearing carriages	1,000.00
Nov. 9.	Construction of two ammunition carts, complete with shafts, etc., design of H. F. L. Allen	700.00
Dec. 5.	Construction of one mechanical difference chart, design of Capt. H. E. Cloke, Artillery Corps	100.00
1902.		
Jan. 6.	Experimental installation of equipment for fire control in Pensacola Harbor	15,000.00
11.	For 200 new model Colt's automatic pistols	4,000.00
23.	Ammunition used in experimental test of shields	158.20
Feb. 8.	Light field carriage for machine guns, design of Capt. J. H. Parker, U. S. Army	1,000.00
8.	To reimburse Ordnance Department for repair of damage caused by bursting of Brown wire-wound gun	589.91
8.	Experiments with live targets	30.00
8.	Expenses of inspection of 6-inch Bethlehem gun	200.00
Mar. 5.	Front disk for telescopic bore sight, design of G. H. Powell	50.00
5.	Construction of 4½-inch face-hardened steel shield for test at works of Bethlehem Steel Company	7,600.00
6.	Construction of 100 rifles embodying modifications suggested by Col. F. H. Phipps	1,700.00
Apr. 5.	Ammunition for test of Bofors 15 cm. gun, additional	1,673.00
5.	Ammunition for test of Vickers-Maxim 6-inch gun, additional	4,794.00

Allotments during the year—Continued.

1902.			
Apr. 5.	Experimental installation of equipment for fire control in Pensacola Harbor, additional	$5,000.00	
5.	Mechanical difference chart, design of Capt. H. E. Cloke, Artillery Corps	75.00	
May 1.	Construction of modified type, a position finder	2,000.00	
1.	Wiring gun and mortar batteries for experiments in fire control	2,000.00	
1.	Ammunition, etc., for test of field guns	690.00	
8.	Auditor's settlement for stationery and miscellaneous supplies to April 29, 1902	509.45	
June 25.	Experimental steel shield, face hardened, 4½ inches thick, of Ordnance design	10,640.00	
25.	Comparative test of cemented and noncemented steel plates	3,000.00	
25.	Expenses and salary of record clerk incident to test of field guns at Fort Riley	520.00	
25.	Experimental material for fire control at Fort Wadsworth, additional	1,459.83	
30.	Expenses of the board for the year	14,471.42	
			$106,396.53
			214,715.48

RECAPITULATION.

Balance on hand and appropriated during the year	$309,662.53	
Allotments revoked and balances made available	11,449.48	
		$321,112.01
Allotments during the year		106,396.53
Available for allotment		214,715.48

APPENDIX B.

Subjects considered during the year.

Subject.	Proposed by—	Action.
Howell gun carriage		Removal authorized.
Pneumatic gun carriage	Pneumatic Gun Carriage and Power Co.	Additional test rounds furnished.
Isham shell and Tuttle thorite, purchase of.	Secretary of War	Purchase of Isham shell not recommended at this time; compensation for Dr. Tuttle recommended.
High explosives, all tests of		Recommended that they be conducted by the board, as contemplated by law.
Test of Bofors gun		Provision made for.
Pouch for first-aid packet	Maj. J. Van R. Hoff	Allotment for test.
Mountain gun	Bethlehem Steel Co	Provision made for test.
Bridle bit	Pollock Barber	Not recommended.
Gruson turrets	Gruson Iron Works	Filed.
Harbor obstruction	A. M. Duhne	Not recommended.
Electrical obstruction	Roy C. Jackson	Do.
Asphyxiating shell	Luis Auban	Do.
Winged projectile	Frank C. Griffith	Do.
Webbing fasteners	George D. Lamb	Do.
Hobble for horses	Paul W. Amlie	Do.
Duties of the board		Views presented to Secretary of War.
Bore sight	Ordnance Department	Allotment.
Disbursement of funds by the board	Chief of Ordnance	Recommended.
Foreign field artillery material	Foreign manufacturers	Entered in competitive test.
Difference disk	Capt. C. L. Phillips	Not recommended.
Canteen	Thos. J. Pratt	Do.
Ball-bearing projectile	J. M. Alford	Do.
Military automobile, test	Eisenhuth Horseless Vehicle Co.	Postponed for present.
Test of mortar fire		Ordnance Department invited to take advantage of.
Duties of the board		Further expression of opinion for information of Secretary of War.
Pneumatic gun carriage, final payment for.	Pneumatic Gun Carriage and Power Co.	Submitted to Secretary of War for decision.
Equipment of type fire command	Chief of Ordnance	Allotment.
Canteen	Lanz Manufacturing Co	Under test.
Defective war material, information regarding.	Board of Ordnance and Fortification.	Requested, but not approved by Secretary of War.
Shield for 6-pounder gun, weight of.	Chief of Ordnance	Referred to artillery committee.
Hotchkiss 1-pounder automatic gun, test of.	do	To be held for competitive test.
Defective shrapnel	Lieut. Fox Connor	Referred to artillery committee for report.
Isham shells, interior finish of	I. G. Johnson & Co	Filed.
Gun-testing platform	Chief of Ordnance	Allotment.
Field artillery material	Ordnance Department	Entered in competition.
Electrical firing devices in test of gun.	Brown & Munsell	Permission granted to use.
Fuses	H. V. C. Keeson	Allotment.
Artillery officers as representatives of board.		Detail recommended.
Field artillery material	American Ordnance Co	Withdraw from competition.
Difference disks, request for purchase of number.	Capt. C. L. Phillips	Not in province of board.
Replotter boards, distribution of	do	To be made by chief of artillery.
1-pounder automatic gun, request for additional ammunition.	S. N. McClean	Not recommended.
75 mm. field gun, description of	Vickers, Sons & Maxim	Filed.
Bandolier, modification of	Dr. E. T. Gibson	Do.

Subjects considered during the year—Continued.

Subject.	Proposed by—	Action.
Nonfulminate fuse	Prof. F. Ant. Hubbuch	Not adopted.
Interrupted screw for primer plugs	Col. J. P. Story	General Buffington to investigate.
Canteen filter, new model	Mrs. C. S. Parker	Not recommended.
Cannon and dirigible torpedo	Georges de Langor	Do.
Modification of stock of small arm	Dr. Emil Amberg	Do.
Aiming guns at night	W. B. Sinclair, jr	Method not considered practicable.
Fixed ammunition	Chas. F. Shedd	Not recommended.
Telemeter	E. von Paschwitz	Do.
Gun carriage, description	Chev. E. de Freystadtler	Filed.
Wireless telegraphy	L. C. Werner	Not recommended.
Field gun and carriage, ammunition for test.	Capt. I. N. Lewis	Allotment.
Brown wire-wound gun, further test.	Brown & Munsell	Granted.
Field artillery material in competitive test.		Inspected by board.
Program for test of field artillery material.	Artillery committee	Adopted.
Submission of accounts to Auditor direct.		Recommended by board but not approved by Secretary of War.
Explosive cartridge	E. C. Geneux	Not recommended.
"Military gaff"	Thomas Sovy	Do.
Gun	Fred Tatum	Do.
Ammunition for test of field gun	Bethlehem Steel Co	Allotment.
Dismounting Howell and pneumatic carriages.	Chief of Ordnance	Do.
Shields and mounts for 6-pounder guns.	Artillery committee	Type adopted.
Wire-wound gun, repair of	Brown & Munsell	Granted permission.
Mauser automatic pistol, further trial of.	Capt. Fred. S. Foltz	Filed.
Filter and canteen stopper	Hopkins & Hopkins	To ascertain cost.
Voltmeter and ammeter	Louis M. Pignolet	Referred to Chief Signal Officer.
Torpedo system	G. E. Elia	Not recommended.
Ammunition cart	Capt. W. C. Manning	Test witnessed.
Brown wire-wound gun		Damage to, inspected.
Submission of accounts to Auditor	Opinion of civilian member	Recommendation renewed
Status of artillery officers at proving ground.		Opinion of board.
Isham shell	Artillery committee	Further tests.
Ammunition cart	H. F. L. Allen	Allotment.
Service of ammunition, competitive test.		Made at Fort Caswell.
Smokeless powder		To be used in all target practice.
Flexible saddle trees	F. de Thierry	Test recommended.
Condition of modern guns, request for information.		Not approved by Secretary of War.
Mountain gun, request for return of.	Bethlehem Steel Co	Approved.
Ammunition cart	Mrs. W. C. Manning	To be tested in competition.
Docks for coast defense	F. C. de Pringal	Not recommended.
Method of steady flotation	Wm. E. Murray	Do.
Automatic pistol	Theodore Bergmann	Filed to await result of tests.
Aerial torpedoes	Elmer Gates	Board willing to witness experiments.
Test of field artillery material		Program adhered to.
Criticism of its actions by members of board.		Opinion of board regarding.
High-explosive shell	W. S. Isham	Further tests.
Protest against limiting number of rounds in competitive test of field artillery material.	H. Tauscher	Such number of rounds will be fired as may be necessary.
Utility of pneumatic dynamite guns.	Secretary of War	Form of armament is obsolete.
Mechanical difference chart	Capt. H. E. Cloke	Allotment.
Utility of 15-inch smoothbore guns	Secretary of War	Retained until replaced by modern guns.
Competitive test of field guns		Board requests further instructions.
Telautograph	Gray National Telautograph Co	Adopted as a type.
Fuse	B. D. Stevens	Further test not recommended.
Ammunition for test of 75 mm. field gun.	Vickers, Sons & Maxim	Filed for future consideration.
"Mob" or machine gun	R. G. Guptill	Not recommended.
Method of constructing fortifications	Peter J. Nelson	Do.
Blunt-point projectiles	George Edwards	Do.
Luger automatic pistols		Further distribution for test.
Confidential reports of foreign tests	Col. W. R. Livermore	Filed.

Subjects considered during the year—Continued.

Subject.	Proposed by—	Action.
Commutation of quarters for officers on special duty.		Recommended.
Fire control and direction, experiments in.		Allotment.
Test of 6-inch rapid-fire gun	Vickers, Sons & Maxim	Recommended.
Accuracy test of field guns		Opinion of board.
Report of test of mortar fire at Fort Preble.	Board of Officers	Printed for confidential distribution.
Report of experiments with high explosives.	Chief or Ordnance	Filed for future consideration.
System of coast defense	Merritt W. Griswold	Filed.
Modification of stock of small arm	Thos. Sheldon	Not recommended.
System of throwing nitroglycerin	Van L. Hampton, for Gilbert Jared.	Board does not care to further experiment.
Range finding	Wm. Lingham	Not recommended.
System of throwing nitroglycerin	B. C. Pettingell	Board does not care to encourage further investigation.
Device for locating direction of enemy.	Edmond Redmond	Not recommended.
Cartridge with platinum thread attached.	G. H. Modermann	Do.
Position finding	Sergt. T. C. MacGregor	Do.
Substitution of representative		Opinion of board.
Experimental shields	Bethlehem Steel Co	Board inspects.
Automatic pistol, new model	Colt's Patent Firearms Manufacturing Co.	Allotment for test.
Skoda field artillery material	Bethlehem Steel Co	Board will test when presented.
Lewis position finder, modifications in.	Maj. G. N. Whistler	Allotment.
Collapsible globe map	O. W. Eaton	Not recommended.
Breech-loading gun	James McHale	Do.
Sword pistol	H. V. Brandenburg & Co	Do.
Experimental shields	Bethlehem Steel Co	Board witnesses test.
Infantry rifle	J. H. Blake	Will be tested when presented.
Compound accelerating projectile	W. R. Knowles	Not recommended.
System of mortar construction	A. J. Lindsay	Do.
Butt-plate scraper	Edmond Redmond	Do.
Carriage for machine guns	Capt. J. H. Parker	Allotment.
Discontinuance of test of certain field artillery material.	Ordnance Board	Approved.
Damage caused by bursting of gun	Chief of Ordnance	Allotment to cover.
Experiments with live targets	Maj. L. A. La Garde	Allotment.
Expenses of inspection of 6-inch gun.	Chief of Ordnance	Do.
Disbursements by board		Renewal of recommendation not approved by Secretary of War.
Bore sight, disposition of	Chief of Ordnance	Sent to Fort Hamilton for test.
Bore sight, front disk for	G. H. Powell	Allotment.
Shield for rapid fire gun	Bethlehem Steel Co	Do.
Report of test of shields	Artillery committee	Accepted.
Armorl system of wireless telegraph.	Torpedo board	Investigated and not recommended.
Adoption of type	Chief Signal Officer	Opinion of meaning.
Enameled canteen	Dubuque Enameling Co	Tested and not recommended.
Twin-buckle cincha	Hugo Doebler	Do.
Modified service rifle	Col. F. H. Phipps	Allotment for test.
Blanket roll strap	J. H. Tabler	Adopted as type.
Bofors cast-steel gun, test	Commander Gustaf Wahlberg	Recommended.
Combination knife bayonet and intrenching tool.		Not recommended.
Clip for magazine rifle	Mr. Parkhurst	Do.
Noncorrosive metal bits	Popes Island Manufacturing Corporation.	Tested and not recommended.
Report on test of service of ammunition.	Commanding officer, Fort Caswell.	Referred to Chief of Ordnance.
Intrenching tool	J. D. Rhodes	Not recommended.
Report on Phillips replotting board	Col. D. H. Kinzie	Filed.
Prentiss dial telegraph, disposition of	Chief of Ordnance	Sent to Fort Wadsworth for test.
Luger automatic pistol, request for	Lieut. R. McCleave, Second Infantry.	Not approved.
Luger automatic pistol, request for	Capt. S. M. Foote, Artillery Corps.	Approved.
Galvanometers, disposition	Capt. S. E. Allen	Sent to posts.
Smokeless powder, test of	G. W. Lindsey	Information furnished.
Taper roller bearing	Wright Taper Roller Bearing Co	Not recommended.
Electric tide gauge	Sergt. Ernest Dieckhoff	Do.
Reuling system of fire control	M. de Cannart d'Hamale	Do.
"Range keeper"	John Dillon	Do.

Subjects considered during the year—Continued.

Subject.	Proposed by—	Action.
Carriage for machine guns	M. Curtis	Not recommended.
Automatic arm	Stephen E. Bailey	Do.
Bofors cast-steel gun		Allotment for test.
Vickers 6-inch gun		Do.
Experiments in fire control at Fort Wadsworth.	Chief of Ordnance	Discontinued.
Installation for fire control at Pensacola.		Allotment.
Field gun No. 3	Bethlehem Steel Co	Test discontinued.
Cartridge box	Dr. Nicola Cerri	Not recommended.
Ammunition for test of Colt's revolver	Col. J. B. Rawles	Recommended.
Bofors cast-steel gun, report of test	Artillery officers	Filed.
Traction engine	Wm. G. Clark	Not recommended.
Railroad mount	Jacob Maumee	Do.
Gathmann system	Secretary of War	Adverse report.
Under-water fuse	Leopold Julig	Not recommended.
Range tables	Capt. A. M. Hunter	Publication authorized.
Ammunition for test of field guns	Chief of Ordnance	Allotment.
Wiring of gun and mortar batteries	do	Do.
Ammunition for test of automatic gun.	S. N. McClean	Not recommended.
System of obtaining ranges and information.	Charles F. Walter	Do.
Rubber-covered bridle bits	Mrs. P. B. Cavender	Do.
Submarine mine	Paul Pitz	Do.
High explosive shell, tests	W. S. Isham	Board witnesses.
Field artillery at Fort Riley, tests of		Do.
Face-hardened steel shield	Ordnance Department	Allotment.
Comparative test of cemented and noncemented steel plates.	do	Do.
Experimental material for fire control.	do	Do.
Expenses of record clerk	Chief of Ordnance	Do.
Artillery officers at Sandy Hook		Relieved.
Unexpended balances		Revoked and made available for other purposes.
Utility of dynamite gun batteries	Secretary of War	Adverse opinion adhered to.
Mauser automatic pistol	Von Lengerke & Detmold	Further tests not recommended.
Long recoil field gun	Vickers, Sons & Maxim	Purchase not recommended.
Counterpoise for Lewis position finder.	Capt. Albert Todd, Artillery Corps.	Action deferred.
Ammunition for experimental purposes, purchase of.	S. N. McClean	Do.
Automatic rifle-caliber gun	V. P. De Knight Gun Co	Board to examine.
Canteen filter	Wm. H. Michael, for R. O. Stebbins.	Not recommended.
Process of hardening malleable iron.	Parke E. Shee	Under investigation.
Machine gun	McH. Jenkins	Do.
War balloon	C. T. Freid	Filed.
Bullet with thread attached	Janko Kovaccvic	Not recommended.
Device to reduce flash and sound of gun.	S. E. Renner	Do.
Armored turret	P. Albertine, attorney for R. Geelhaar.	Do.
Winged projectile	E. P. Richardson	Do.
Submarine torpedo boat	Alex. Klinger	Do.
Armstrong field-gun carriage	Capt. E. L. Zalinski	Filed.
Aerial inventions	M. J. Bullivant	Not recommended.
Dynamite projectile	Friedrich Ebeling	Do.
Report on aerodrome	S. P. Langley	Filed.

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